UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic Atmospheric Administration
National Marine Fisheries Service
P.O. Box 21668
Juneau, Alaska 99802-1668

June 22, 2016

Ms. Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street
Washington, D.C. 20426

Re: Susitna-Watana Hydropower Project,
FERC Project No. 14241-000;
Review of Initial Study Reports

Dear Secretary Bose:

On January 8, 2015, the Federal Energy Regulatory Commission (FERC) granted the Alaska Energy Authority's (AEA) request to hold the Susitna-Watana Integrated Licensing Process (ILP) in abeyance until further notice. On August 26, 2015, AEA asked FERC to lift the abeyance and continue with the ILP through the determination on requested study plan modifications and need for new studies. On October 27, 2015 FERC lifted the abeyance. In response to FERC's decision to lift the abeyance, the National Marine Fisheries Service (NMFS) provides the enclosed comments, reviews, requests for study modifications, and a request for one new study for the proposed Susitna-Watana Hydropower project (Project).

We note that some of this information was discussed at the October 2014 Initial Study Report (ISR) meeting and at the March 2016 ISR meeting. At those meetings, NMFS provided preliminary comments and recommendations for study modifications and new studies; which are on record in the FERC's docket for this project in the meeting transcripts.[1] Our complete comments and recommendations are contained in this letter and enclosures.

Pursuant to the regulations (18 CFR § *5.15*), which implement the ILP of the Federal Power Act (FPA), we are proposing study modifications and new study requests in accordance with the Essential Fish Habitat Provisions of the Magnuson-Stevens Fishery Conservation and

[1] We are unable to thoroughly review these transcripts. However, due to the poor in-room acoustic conditions and teleconference capabilities there are extensive "indiscernible" notations in the record. We note that despite our limited review, the information provided from both meetings does not reflect an accurate and complete record.

Management Act, the National Environmental Policy Act, Endangered Species Act, Clean Water Act, and the Fish and Wildlife Coordination Act.

Under Section 10(j) of the FPA, NMFS is authorized to recommend license conditions necessary to adequately and equitably protect, mitigate damages to, and enhance fish and wildlife (including related spawning grounds and habitat) affected by the development, operation, and management of hydropower projects. Also, under Section 18 of the FPA, NMFS has authority to issue mandatory fishway prescriptions for safe, timely, and effective fish passage for anadromous fish. This includes prescribing that passage be provided by the applicant/licensee (Alaska Energy Authority) for 1) adult salmon migrating upstream past the proposed dam location on the Susitna River to spawning sites in tributaries above the proposed reservoir; and, 2) juvenile salmon migrating downstream from those spawning and/or rearing sites to sloughs and other rearing habitats and outmigrating from the river to the sea. Additionally, Section 10(a)(1) of the FPA requires FERC to condition hydropower licenses to best improve or develop a waterway or waterways for the adequate protection, mitigation, and enhancement of fish and wildlife (including related spawning grounds and habitat) based on NMFS's recommendations and plans for affected waterways.

General Considerations

As part of the ILP, the applicant is required (18 CFR § *5.15)* to conduct studies that will result in data and analysis to inform our recommendations to FERC with regards to licensing the Project. Information on the collective estimates of fish abundance, by species and lifestage, and valid and reliable models to forecast dam effects under various operational scenarios, is extremely important to that effort. NMFS points out that modern scientific estimates are typically accompanied by estimates of sampling error; usually expressed as confidence intervals or standard errors, and notes that these have been absent in many of the reports reviewed to date. We wish to be clear that we consider estimates of sampling error to be a standard practice to be included in scientific studies of this kind. Further, we highlight studies 8.5, 9.5, 9.6, 9.7, as studies where the sampling error estimates are required.

Specific Considerations

<u>Data Issues</u>

We recognize that the Alaska Energy Authority (AEA) has done an immense amount of scientific work related to characterizing the potential impacts related to the Project. However, the material provided to date does not meet our needs to analyze and forecast the impacts from the Project on resources of our concern. To date, much of the effort to sample for fish abundance has produced a large amount of data that has yet to be summarized. Currently, we still lack estimates of abundance that can be used for statistically valid estimates and meaningful comparisons. This is likely because much of the data was not collected in a consistent manner that allows statistical comparisons. Similarly, there are problems with the data due to

- misidentification of fish;
- lifestages were not recorded; and
- species were combined or similar problems.

Analysis Questions

More importantly, we have not been provided with information that demonstrates that the preliminary models to forecast dam effects are adequately constructed, statistically valid, or otherwise capable of providing reasonable forecasts of impacts from the Project. As written, the descriptions of the modeling efforts do not meet accepted scientific standards and leaves us concerned about the modeling effort and data collection to support it.

Organizational and Structural Issues

Lack of a comprehensive and consolidated stand-alone study report, containing sufficient descriptions of study goals and study methods has diminished our ability to fully review all the information within the time allotted. We note that our review included approximately 15,000 pages of various study reports, technical memos, appendices, errata, and other results and data that were scattered throughout many other reports and databases. In many cases data was difficult to locate or incomplete. Further, our review was further complicated by the lack of clear and complete descriptions of the methods that were used for data summarization, model construction, and model validation.

AEA initially asserted that the March 2016 ISR meeting was intended to be to be a "cumulative" ISR meeting and meant to replace the October 2014 ISR meeting. However, not all of AEA's studies were covered in the March 2016 meeting. Several studies were last discussed during the October 2014 ISR meeting. On April 25, 2016 AEA filed an "ISR Meeting Summary," including AEA's proposed modifications to studies. FERC determined in December 2015 that this information, along with about 50 new volumes of material AEA provided (August 2015), and the many reports and data compiled from the past years of irregular and partial studies meets the intent of the ILP regulations for the ISR. NMFS respectfully disagrees with FERC's determination because the ISR meeting did not cover all of the information which it would need to for it to be cumulative and to comprehensively cover all of the study results to date, as intended.

Environmental Conditions

FERC required requests for study modifications show good cause and that either 1) studies were not conducted provided for in the approved study plan; or 2) the study was conducted under anomalous environmental conditions. While most of the issues we describe can be corrected, one important limitation to the information in the studies conducted so far is that the data were collected under anomalous or unusual environmental conditions in the study years. Southcentral Alaska experienced record warm conditions in the past two winters with the average winter temperature 5-6 °C above the long-term average. Analysis of stations in Southcentral Alaska, including Talkeetna, found an increase in warm extremes (the warmest 1% of daily high temperatures) as well as a 100% decrease in the frequency of cold extremes (coldest 1% of daily lows). A 50-year flood occurred on the river in 2013 and the September 2012 flooding of the Susitna River was a result of the seasonally anomalous weather system (precipitation 300% above normal). Flooding from both years likely caused scouring of salmon redds and displacement of salmon juveniles. This would affect the success of fish spawning, reduce the abundance of juvenile salmon, and affect juvenile fish distribution in 2013 and 2014.

Additionally, the latest spring breakup on record occurred in late May of 2013; delaying the start of fish sampling and affecting the ability to sample juvenile salmon during outmigration. The winters of 2014-2015 and 2015-2016 were characterized by unusually warm temperatures in mid-winter causing an abundance of open-water and ice jamming. Additionally, these were years of unusually low adult Chinook Salmon returns and years when older age classes were reduced in the adult returns.

Due to these recent anomalous weather patterns we are concerned that project studies do not accurately represent Susitna River baseline resources and cannot serve as an adequate basis for assessing any future project impacts. Additional years of study must be conducted to determinate the value of data collected in these years of anomalous conditions.

Overview of Review and Recommendations

Modified Study Requests

NMFS is requesting many Study Modification Requests. Many of these requests correspond to studies that were not conducted as provided for in the approved study plan or correspond to variances from the approved study plan. All were conducted during years of environmentally anomalous conditions. Importantly, the basic process of how the results of how each study and collectively all studies will be used to estimate project effects on fish and fish habitats must be clearly described, with predetermined levels of acceptable accuracy and precision.

We stress the need to improve the planning and reporting of the studies and the written description of the methods. In order to make an informed analysis it is critical that all study reports contain accessible, detailed, clear, and specific descriptions of statistical methods. Therefore, NMFS recommends that 2014 data not be considered as year-two Project data until FERC determines that information collected in 2013 meets the approved sample plan determination requirements.

Also, NMFS recommends that AEA develop operational plans for any additional fieldwork, and that these plans contain (1) a clear statement of the overall goals of the sampling or field effort and a statement of what the effort is intended to produce; (2) a list of each statistical estimate that the sampling is intended to produce; (3) a statement of the intended statistical precision for each estimate and a statement of how that precision will be sufficient to meet the overall project goals; and (4) a clear statement of all methods in sufficient detail for an independent scientist to be able to repeat every aspect of the study.

New Study Request: Model Integration and Decision-Support System (DSS)

We propose a new study request for Model Integration and DSS to help address our concerns regarding appropriate characterization and evaluation of Project effects. AEA proposes to evaluate resource baseline characterization and Project effects using a conceptual plan dependent upon integration of multiple modeled studies. The new model integration study proposal is requested for the purposes of determining how or if the data produced by the interrelated studies will or can be integrated. An independent effort to study the integration of models is needed for the overall approach to evaluate Project effects. Similarly, the overall approach to evaluate Project effects relies upon several structured DSS models (e.g., Fish Passage, Instream Flow, Riverine Processes), which are linked to model integration. The DSS is an integral component of model integration for baseline characterization and predicting Project-effects. NMFS respectfully requests that our concerns on these topics be supported by FERC in the updated study determination for this project.

To date efforts at study integration have been insufficient, consisting of two model integration workshops and a very limited proof of concept effort, involving integration of only a few modeled studies at one focus area. This limited effort at model integration was not very successful. The ILP process has identified many limitations and inconsistencies in the models. AEA has also recognized the importance of such an effort in the conceptual drawings of model integration included in the *Study Implementation Report for Study 8.5, Fish and Aquatics Instream Flow* (on pages 96-97). This study is necessary to determine how the information produced by the interrelated studies or can be integrated in a scientifically and statistically valid manner. A focused effort to study the large, highly complex task of model integration is needed. Similarly, the overall plan of study relies upon several structured decision support models (e.g., Fish Passage, Instream Flow, Riverine Processes), which are linked to model integration. The decision support systems are integral parts of the Model Integration approach to studying the environmental baseline and predicting project effects. These systems require early development and are not efforts best left to the end of the pre-licensing studies.

The Integrated Licensing Process

The ILP was intended for relicensing existing hydropower projects and to streamline FERC's licensing process by providing a predictable, efficient, and timely licensing process while ensuring adequate resource protections. The ILP was intended to engage stakeholders and produce early problem identification so as to fill information gaps. In part, the decision to use the ILP for this original license was based on the applicant's assertion that no anadromous fish existed upriver of the proposed dam site, no species listed as threatened or endangered under the Endangered Species Act would be affected by the project, and that stakeholders would be involved in developing studies that would be conducted prior to the ILP studies. In fact, studies since 1982 have shown that Chinook Salmon do spawn above the proposed dam site, listed species (Cook Inlet beluga whale) may be affected by hydropower operations, and stakeholders were not involved in developing pre-ILP studies.

After five years of effort, NMFS is only now able to fully review results from the "first year" of study. The ILP intends for review and modification of studies to happen annually. Despite awareness of significant issues that had been brought to AEA and FERC's attention many times, AEA continued to implement studies during the ILP abeyance without NMFS reviews and recommendations. The intended efficiencies of the ILP process have not been realized. The reporting of methods and results has been highly problematic. Our ability to timely and adequately provide necessary scientific reviews and develop necessary recommendations has been constrained. For these and other reasons, we recommend that further use of the ILP should be reconsidered. Our original request for a modified ILP for this one-off project is still preferred.

Enclosures

Enclosure 1 contains requests for study modifications. Study titles and numbers as assigned by AEA organize these detailed comments, which begin with our study modification requests from the March 2016 ISR meeting. Study modification requests from the October 2014 ISR meeting and June 2014 ISR are located in the body of each study section. For each of our Modified Study Requests we provide supporting documentation and justification of good cause as to why the study should be modified. We show that either: (1) approved studies were not conducted as provided for in the approved study plan or (2) the study was conducted under anomalous environmental conditions or that environmental conditions have changed in a material way. Many studies were not conducted as provided for in the approved study plan, with numerous variances and modifications as described. Additionally, anomalous conditions are as described above.

Enclosure 2 is NMFS's request for a new study: Model Integration and Structured Decision Support, as previously described above.

Enclosure 3 is the Strategic Action Plan of the Mat-Su Salmon Habitat Partnership: *Conserving Salmon Habitat in the Mat-Su Basin (2013, Update).* This is provided as a comprehensive plan under Section 10(a)(2)(A) of the FPA, for FERC's use in considering the extent to which a project is consistent with Federal or state comprehensive plans for improving, developing, or conserving a waterway or waterways affected by the project. As required by FERC to qualify as a comprehensive plan, this plan is a comprehensive study of one or more of the beneficial uses of a waterway or waterways. This comprehensive plan was developed by local governments, state and federal fisheries managers, Native Alaskan organizations, and non-governmental partners. The plan contains a description of the waterways that are the subject of the plan, including pertinent maps detailing the geographic area of the plan; a description of the significant resources of the waterways; a description of the various existing and planned uses for these resources; and discussion of goals, objectives, and recommendations for improving, developing, or conserving the waterways in relation to these resources. It also includes descriptions of the significant resources in the area such as navigation; power development; fish and wildlife; recreational opportunities; water supply; and other aspects of environmental quality. The plan examines how the different uses will promote the overall public interest. This comprehensive plan will be useful to FERC in assessing the consistencies of NMFS license recommendations for the adequate protection, mitigation and enhancement of fish and wildlife (including related spawning grounds and habitats) with the plan's goals, objectives and recommendations.

NMFS believes that to protect the State's considerable investment (over $180 million in the current effort and over $250 million expended in the 1980s effort) for this license application all of the study results and data be consolidated in a stand-alone, archival format that preserves and maintains the data themselves along with the reports. Also, reports should receive independent external peer review. This is a standard practice for hydropower projects of this magnitude and ensures that sound science informs decision making as it relates to environmental concerns in implementing engineering design. Finally, we recommend that some of these results be published in the peer-reviewed literature. This would allow this investment in the Susitna River to be useful and worthwhile in any continued or future project through validation of study methods, analysis and conclusions.

In conclusion we hope this information will be useful to inform FERC's determination. If you have any questions, please contact Susan Walker at (907) 586-7646 or at susan.walker@noaa.gov.

Sincerely,

for James W. Balsiger, Ph.D.
Regional Administrator, Alaska

Enclosure 1: Study Modifications Requests
Enclosure 2: New Study Request: Model Integration and Decision Support Systems
Enclosure 3: Conserving Salmon Habitat in the Mat-Su Basin; The Strategic Action Plan of the Mat-Su Salmon Habitat Partnership

cc: e-file under FERC Docket P-14241 as distribution

Enclosures

Enclosure 2. NMFS New Study Request	Pages
Model Integration and Decision Support Study Request	1-15

Enclosure 3. Comprehensive Plan	Pages
Strategic Action Plan of the Mat-Su Salmon Habitat Partnership: Conserving Salmon Habitat in the Mat-Su Basin (2013 Update)	

5.5 Baseline Water Quality

ISR Review and Study Modifications

The National Marine Fisheries Service (NMFS) reviewed the body of comments, meeting summaries, and meeting comments related to water quality since the Alaska Energy Authority's (AEA) released the Final Initial Study Report (ISR) on June 3, 2014. These comments focus on the review of the Susitna-Watana Hydropower Project (Project), Water Quality Baseline Study, Study Plan Section 5.5, Final ISR (AEA, June 2014). Since the ISR was issued, AEA has released or presented additional study plan information and errata including:

- 2014 Study Season Technical Memoranda, September 30, 2014
- ISR Meeting Presentation Materials, October 16, 2014
- Errata Release & Additional 2013 Sampling Data, November 14, 2014
- Part D - Supplemental Information to June 2014 ISR Report, November 2015
- Study Completion Report (SCR) for Baseline Water Quality, November 2015
- Quality Assurance Project Plan (QAPP) in Final ISR, Section 5.5, Part B, June 2014
- ISR Meetings, Agenda, Meeting Summary, and Presentation, March 23, 2016

Due to misunderstandings and limited funds, NMFS's contractors only had time for a cursory review of document documents submitted after the Final ISR in 2014.

Study Objectives

The objectives of the Baseline Water Quality Study, as specified 2013 Revised Study Plan (RSP) are summarized as:

1. Document historical water quality data and combine this information with data generated from this study. The combined data set will be used in the water quality modeling study to predict Project impacts under various operational scenarios.
2. Add three years (2012–2105) of current stream temperature and meteorological data to the existing data set. An effort will be made to collect continuous water temperature data year-round with the understanding that records may be interrupted by equipment damage during river floods, ice formation around the monitoring devices, ice break-up and physical damage to the anchoring devices, or removal by unauthorized visitors to the site.
3. Develop a monitoring program to adequately characterize surface water physical, chemical, and bacterial conditions in the Susitna River within and downstream of the Project area.
4. Measure the baseline metal concentrations in sediment and fish for comparison to State of Alaska criteria.
5. Perform thermal imaging assessment of a portion (between Talkeetna and Devils Canyon) of the Susitna River. The thermal assessment results will be used to map groundwater discharge and the possible extent of thermal refugia, as specified in the Executive Summary of the ISR.

Federal Energy Regulatory Commission (FERC) approved the above stated objectives in their Determination (4/1/2013) and also recommended changes to the Standard Operating Procedures (SOP) and QAPP, specifically:

6. Implementation of Environmental Protection Agency (EPA) 1631E method for laboratory analysis of total mercury in water, sediments, and fish tissue, and EPA Method 1630 for laboratory analysis of methylmercury in water and fish tissue, and application of Method 1669 (Clean Hands/Dirty Hands) for all mercury field sampling.
7. Utilization of Toxicity Reference Values (TRVs) as an additional benchmark when evaluating the need for additional baseline water quality data collection.

The Baseline Water Quality Study was not implemented in accordance with FERC's determinations and recommendations in the approved study plan. NMFS has significant concerns about the quality of the water chemistry and water quality data collected in 2013, as well as decisions made using these data as inputs. NMFS does not agree that the study is complete and therefore does not believe the SCR should not have been written.

NMFS Study Modifications

NMFS recommends the following modifications to address the above study objectives:

1-1 Collect additional data to eliminate spatial discontinuities in both grab samples and continuous sampling.

3-1 Collect another complete year of water chemistry, water quality, and groundwater data at all sampling sites and focus areas because the majority of water chemistry data collected in 2013 was disqualified due to quality control problems (Objectives 1, 2, & 3).

4-1 Collect sediment samples in slack water areas to determine baseline metals concentrations and assist with the understanding of mercury methylation potential. A target water condition and a single sampling method should be selected and then used consistently.

5-1 Complete the Thermal Infrared Remote Sensing (TIR) as was originally scheduled for 2014.

7-1 Provide a table of actual toxicity reference values (TRV).

G-1 (Global Modification). Data quality issues and the approach used to resolve data quality issues with suspended solids, holding times and temperatures be described in greater detail in a data quality report.

The ISR states the methods for the Baseline Water Quality Study were developed to satisfy the calibration needs of the water quality models, establish consistency with historical data collection on the river, and meet the requirements of the 401 Water Quality Certification Process. One of the purposes of collecting baseline water quality data is to calibrate the Water Quality

Model (5.6). NMFS recommends that the following three issues deserve further consideration in the application of baseline water quality data in this calibration effort, specifically:

- The draft ISR stated that two types of modeling analyses are currently being conducted: (a) pathway model analysis to evaluate potential for transfer of contaminants between different media (sediment – pore water, pore water – surface water, surface water – fish tissue; and (b) numerical modeling. While some details are provided on the numerical model in ISR Study 5.6, it is essential to obtain more details on the pathway model analysis and its relationship to the numerical model to be able to evaluate the use of these approaches in evaluating project impacts.
- It is not clear that there is sufficient data to accurately model water quality in the focus areas. There is a need to increase the resolution of the water quality modeling grid in these Focus Areas. The accuracy of model predictions (e.g. contaminant concentration per cell) and the uncertainty around these estimates increases with smaller grid size (i.e., increased grid refinement), however; smaller grid sizes require more data. Determination of the level of resolution needed to detect differences in water quality parameters between groundwater and surface water in side channels and sloughs (particularly temperature and dissolved oxygen) under different operating scenarios will be critical to evaluate project effects. As such, the collection of tributary data for use in model calibration requires further description in the reports, as the level of detail currently provided does not allow for an evaluation of how these data will be used. NMFS recommends that AEA sample zooplankton based on known chemical transport mechanisms (see literature review in comments on study 5.7 for a discussion of the potential role of zooplankton in the downstream transport of mercury from newly formed reservoirs). Currently, additional environmental media will only be sampled for metals should exceedances be observed in water, sediment, and fish tissue. Establishment of baseline concentrations in these organisms will be important to the calibration and evaluation of bioaccumulation modeling results, and should be incorporated into the upcoming field sampling program rather than being sampled only if metal concentrations are elevated in fish tissue.
- Integrating the water quality model specifically with the mercury modeling effort (5.7), River Productivity (9.8) and the groundwater model poses many challenges. Additionally, the water quality model needs to be tied to the open water flow routing model (8.5) and the Ice processes models (7.6). It is not clear that this is possible

Additional comments regarding how the water quality baseline sampling may impact the modeling program can be found in NMFS' comments on studies 5.6 and 5.7.

Review by Objective

Objective 1: *Document historical water quality data and combine this information with data generated from this study.*

<u>Conformance with Objective 1</u>

An attempt was made to provide more comprehensive discussion of how the data collected in the 1970s/1980s compares with more recent data acquisitions (Section 6, Table 6.0-1). However, it would be useful to have some understanding of how such issues as prevailing weather (temperature, snow/ice cover), flow and geomorphic conditions compare between the times of the original sampling to the present. For example, were summer conditions particularly wet/dry, hot/cold when the samples were obtained in the 1980s? How might this affect the results in comparison with more recent data? This information would be useful when calibrating water quality modelling. There is a danger that the model would be calibrated only to replicate the specific conditions that occur where acceptable data quality is available. This may become skewed in favor of more recent monitoring. More specifically, there are significant and unexplained differences in the concentrations of dissolved calcium and magnesium (increased 1,000 times during existing summer conditions compared with the summer of 1980).

The SCR included a comprehensive map (Figure 4.1-1) showing the project river miles and sampling/monitoring gauges specifying the monitoring period at each station.

Modification 1-1: NMFS recommends that additional data be collected to eliminate spatial discontinuities in both grab samples and continuous in-situ sampling.

Collection of these data will help in the development of more accurate hydrodynamic and water quality models, which is necessary for NMFS to accurately assess project impacts and develop necessary mitigation measures.

There was no continuous water data collected downstream of Project River Mile (PRM) 90, and there are several 30+ mile reaches in the river above PRM 90, where no data have been collected due to access issues.

The study was not conducted as provided for in the approved study plan because the distances between sample points were too large.

Modification 3-1: NMFS recommends that another complete year of water chemistry, water quality, and groundwater data be collected. This applies to both Objective 1 & 3 but will be discussed under Objective 3.

Objective 2: *Add three years of current stream temperature and meteorological data to the existing data set.*

<u>Conformance with Objective 2</u>

The success of monitoring during winter 2013/2014 (all 19 thermistor’s data were recovered), and monitoring during summer 2014 (all 36 thermistor data were recovered) provided one continuous period of data set in the Upper Susitna River, with an exception of recognized data gaps (page 4 – variances, SCR).

The number and locations of water temperature monitoring sites were reduced from 37 to 36 sites. NMFS is not concerned about this minor variance.

The project QAPP called for redundant data loggers at each site (the second instrument to be installed as a bank-mounted pipe system). AEA found it impractical and/or unsafe to implement this protocol at many locations. The overwinter anchor and buoy systems were shown to be resilient and had better survival rates than the bank mounted thermistor systems. NMFS does not have concerns about this variance.

Continuous water temperature loggers between PRM 145.6 and the Oshetna River confluence (PRM 235.2) had different periods of record due to late start of deployment in 2012, loss of logging equipment due to ice break-up (winters 2012/13 and 2013-14), and site access issues in 2013. NMFS is concerned about loss of data accuracy and spatial precision.

Modification 3-1: NMFS recommends collecting an additional year of stream temperature data when the additional year of water quality data is collected. See justification under Objective 3.

Objective 3: *Develop a monitoring program to adequately characterize surface water physical, chemical, and bacterial conditions in the Susitna River within and downstream of the Project area.*

<u>Conformance with Objective 3</u>

Since publication of the ISR, AEA has attempted to address the three major issues identified in our previous comments (February 25, 2014), specifically: (3.1) Lack of data from the 50 mile river reach area; (3.2), serious problems with the collection, chain of custody, and analysis of representative 2013 baseline samples, and (3.3) the stated intention to use a “correction factor” to adjust 2013 data concentrations.

(3.1) The 50-mile reach of Susitna River (including Tsusena Creek), previously inaccessible due to land ownership issues, was successfully sampled in summer of 2014.

NMFS believes winter monitoring was not conducted in that reach and NMFS recommends that this should be included. Rather than three years of water data there is one summer of data in this reach.

(3.2) AEA provided a summary of all data collected during the 2013 and 2014 sampling seasons, laboratory data reports, and quality control sheets and explained how data was contaminated, rejected, and consequently resampled (SCR, pp 15-16).

While NMFS looked through this information, our contractors did not have time to conduct quality control of these results. However, we noticed a significant discrepancy in the percentage of the rejected samples (9% - 30%, according to Table 5.1-1), compared to 90% of rejected samples according to our analysis of the 2013 metadata (February 25, 2014 Technical Memo, USFWS and NMFS consultants, Environ). Thus, NMFS recommends that AEA should explain why the 2013 data previously rejected, have now been accepted in the analysis. Non-conformance with this objective, if confirmed, is significant.

(3.3) AEA has provided an explanation of the total phosphorus (TP) conformance factor, however, some of the values in Tables 4.5-3 and 4.5-4 are doubtful [corrected TP was calculated as -0.065 (Table 4.5-3), estimate % of TP that is due to TSS was calculated as 128.8%], raising questions on the methodology applied. If there were only one consistent and explainable quality control issue associated with the 2013 data results, the application of a correction factor might be appropriate, after careful review of the procedure to be used. However, the issues associated with the 2013 data are multiple, and diverse, so NMFS believes that the application of the TP Correction Factor may be inappropriate.

Water Quality

Two types of water quality data were collected: in-situ data and field samples sent for analysis by an accredited laboratory. The in-situ data included dissolved oxygen (DO), acidity (pH), specific conductance, color, redox potential, and chlorophyll a. A large portion of the laboratory processed samples were labeled as “qualified” in several data validation reports.

- One of the monitoring stations was moved from PRM 225.5 to PRM 235.2 due to limited site access. NMFS agrees that this relocation will not jeopardize the water quality model.
- During winter of 2013/14 baseline monitoring, samples were collected in January instead of December, and at PRM 187.2 rather than PRM 185. NMFS agrees that both variances have minimal effect on study results.
- The TP detection limit of 3.1 micrograms per liter (used in 2013 samples) was lowered to 2.0 micrograms per liter in processing 2014 samples. NMFS agrees that this lower detection limit will improve accuracy
- Additional water quality sampling occurred in 2014 at selected locations and for parameters for which 2013 samples were qualified as either “rejected” or “estimated”. However, all the 2014 samples were “single grab sample-types” based on the conclusion that there was no horizontal or vertical variability at sample locations (from 2013 samples). NMFS questions the validity of that conclusion, as it could have been based on the 2013 samples that were previously rejected.

Another decision made based on the 2013 data was to conduct sampling in 2014 using a single grab sampling method. All the 2014 samples were “single grab sample-types” based on the conclusion that there was no horizontal or vertical variability at sample locations. The problems with the data collection in 2013 may have led AEA to an erroneous conclusion because it is difficult to assess variation using questionable data. Additional water quality sampling occurred in 2014 at selected locations and for parameters for which 2013 samples were qualified as either “rejected” or “estimated.” NMFS questions the validity of the lack of variation in the data, as it was based on 2013 samples that were rejected.

Focus Area Water Quality Monitoring-More sampling points (up to six) along each transect were included within each Focus Area than originally identified in the Revised Study Plan (RSP). NMFS agrees that this variance will improve resolution in modeling of the focus area.

Groundwater - Groundwater samples were collected from wells in four Focus Areas. However, the Final ISR included only samples processed and analyzed before August of 2013. No anomalies were detected in the results presented through August 2013 period.

Shallow groundwater was not identified in the Focus Areas closest to the proposed dam site. The proposed reservoir area will experience alternating groundwater levels and increased surface water-groundwater connectivity in previously unsaturated strata under operational scenarios. The TIR data may help distinguish areas of the Susitna River subject to complex hyporheic zone processes and those that are not but does not preclude necessary analyses of ground and geological conditions in the vicinity of the dam.

Wells for groundwater sampling had to be moved from the end of each main transect to area where they could be successfully installed, and more aligned with the groundwater wells from the groundwater study. This change would improve likelihood of measuring groundwater interaction with surface water. A planned groundwater well installed at the downstream end of Focus Area 138 did not have sufficient recharge rate, indicating little surface water – groundwater interaction at this location. Additional groundwater samples were not collected in 2014, although the data collected in 2013 were suspect and required additional sample collection to further support 2013 efforts.

Modification 3-1: NMFS recommends collecting another complete year of water chemistry, water quality, and groundwater data be at all sample sites and focus areas.

The majority of water chemistry data collected in 2013 was disqualified due to quality control problems. (i.e., sample preservative affecting detection of the target analyte, bottles of reagent water were contaminated with the target analyte(s), etc.). It is therefore recommended that data collection be extended for another year to compensate for the inadequacy of 2013 data. NMFS does not support the AEA's proposed use of a total phosphorus correction factor for the 2013 data; the application of a correction factor to poor quality data is likely to result in additional poor quality data. In addition, the issues associated with the 2013 data are multiple and diverse. The application of this factor would not correct for all of them.

The study was not conducted as provided for in the approved study plan because the 2013 data is not useable.

Objective 4*: Measure the baseline metal concentrations in sediment and fish for comparison to state criteria.*

Conformance with Objective 4

Methods to assess the baseline metals in fish tissue are provided in the Study 5.7 ISR. The SCR provided no additional information on this objective.

Sediment Sampling- Four instead of ten sites were sampled in 2013 due to land access restrictions. Sediment was sampled using hand auger or stainless steel spoons. This change was necessitated by restrictions on sampling equipment weight imposed by helicopter use (instead of boats) to access sampling locations. NMFS agrees that this change in sampling technique should not affect quality of the collected sediment data.

The SCR report confirms that all surface water sample collection avoided pools or slack water. However, sediment samples were taken from slack water areas. Any comparative water quality analysis will need to address this discontinuity. Given that fine sediment with higher organic carbon content is often localized in these areas, this avoidance has large implications for baseline metal concentrations and especially for mercury methylation modeling, which depends in part on organic carbon and sulfate concentrations in sediment. For example, if an appraisal of leaching of metals from sediments into water is carried out, then this will need to recognize that the impact would be directly to water in pools/slack water areas and not necessarily to the main river flow. No supporting discussion or revisions to sediment sampling to address this issue have been provided.

This is a problem and NMFS recommends that this should be corrected prior to subsequent year of sampling.

Modification 4-1: NMFS recommends collecting sediment samples in slack water areas to determine baseline metals concentrations and to assist with the understanding of mercury methylation potential. A target water condition and a single sampling method should be selected and then used consistently. NMFS recommends that AEA should specify which fish tissues were collected for metal analysis and in the future grind up and analyze the whole fish.

The applicant altered sampling techniques for explained logistical reasons. They flip flopped on where samples should be taken for an unexplained reason. The SCR states that there was a change in sample collection methodology from Ekman Dredge and van Veen to hand auger and/or stainless steel spoon. NMFS recommends that AEA describe the comparability of sample collection methods, particularly for capturing fine grained sediments.

AEA also only sampled metals in fish fillets. Metal tends to concentrate in internal organs and wildlife and beluga whales consume the whole fish. Therefore the transfer of mercury and other metal may be underestimated. This level of detail was not stated in the RSP.

The study was not conducted as provided for in the approved study plan.

Objective 5: *Perform a thermal imaging assessment of a portion (between Talkeetna and Devil's Canyon) of the Susitna River. (Note – the description of the geographic extent of this area varies between documents.)*

<u>Conformance with Objective 5</u>

The main objective of TIR in 2013 was to collect thermal data for the Focus Areas and for the Lower River. This is important for understanding groundwater/surface water interactions. The TIR sensing methodology was largely successful in 2012, collecting TIR data for large sections of the mainstem of both the Lower and Middle rivers. In contrast, the TIR sensing effort was minimally successful in 2013 in collecting data for the Focus Areas. AEA had planned to complete the TIR sensing effort in 2014 for the remaining areas but this effort was abandoned; the initial spatial goal of Talkeetna to Devil's Canyon was never completed.

Data Acquisition for this technique requires that the air temperature be cold, with no wind, no ice on the river, and no precipitation during the sampling flights. In 2013, six weeks of effort during October through November of 2013 resulted in only five days of usable data, including all the Focus Areas, and 73% of the Lower River.

This technique, although not complete, identified numerous groundwater contributions in eight (of ten) Focus Areas. The remaining two Focus Areas showed only minimal groundwater activity. Temperature data derived from the TIR analysis showed relatively good correspondence with temperature data from the in-stream sensors, where these sensors were located close to the identified source of groundwater upwelling.

The methodology for data interpretation is not well described. For example, what criteria were used by the analyst to determine whether "increased groundwater activity" had been detected? It is not clear from the images reproduced in Appendix J.

Water temperature, water quality, hydraulic head depth at between 0.15 m and 0.3 m below the river or stream bed can supplement TIR to clarify the relationship between hyporheic conditions and incubation periods for indicator species. There is evidence based on salmon-spawning rivers (although not in Alaska) that dissolved oxygen in particular can vary considerably at 0.3 m depth and is strongly linked to river discharge (Malcolm et al, 2006; Environment Agency 2009).

TIR is relatively constrained by weather conditions and the fact that temperature differentials between surface water and groundwater are lower in Alaska than in other areas of the United States. Caution must be applied when using TIR data to interpret hyporheic mechanisms and their implications for year-round water quality and habitat characteristics. Prevailing weather can alter surface water – groundwater interactions. For example, a cool, dry summer may lead to lower river flows due to reduced snow melt and a greater influence from groundwater base flows.

Caution should be exercised in interpretation of results from remote sensing applications, especially where there is potential for anomalous results. A clear distinction should be drawn between the use of TIR for identifying areas where there is strong potential for surface water – groundwater interaction at certain times of the year and in-situ field data for baseline water quality monitoring.

There is no information in the ISR about other potential means of determining groundwater-surface water interactions such as hydrochemical tracers.

Modification 5-1: NMFS recommends that the Thermal Infrared Remote Sensing (TIR) be completed as originally planned for 2014.

TIR sensing is an important component of the study and should not have been discontinued.

The element was not brought to completion as the applicant suggested it would be. The utility of TIR to help understand project effects is greatly diminished if important areas are not completed.

The study was conducted as provided for in the approved study plan. However, considering that the applicant is finding the data useful and had planned to do the last few areas, NMFS suggests that the applicant complete this TIR data collection.

Objective 6: *Implementation of EPA's 1631E method for laboratory analysis of total mercury in water, sediments, and fish tissue, and EPA Method 1630 for laboratory analysis of methylmercury in water and fish tissue, and application of Method 1669 (Clean Hands/Dirty Hands) for all mercury field sampling (FERC added objective).*

<u>Conformance with Objective 6</u>

Implementation of the EPA methods for laboratory analyses of mercury and methylmercury has been included in the Final ISR (revised QAPP document) (Table 12b, Section 5.5, Part B, and Attachment 1). A more detailed discussion can be found in the Objective 3 section above.

No modifications are recommended for Objective 6.

Objective 7: *Utilization of TRVs as an additional benchmark when evaluating the need for additional baseline water quality data collection (FERC added objective).*

<u>Conformance with Objective 7</u>

The Final ISR confirmed that AEA has accepted FERC's recommendation for the use of TRVs "as an additional benchmark when evaluating the need for additional baseline water quality data collection." However, no details have been provided as to the specific TRVs to be incorporated, or how they would be applied in determining additional sampling needs for the upcoming field season. Although it has been noted that TRVs will be used in the evaluation of the baseline data (Final ISR, Section 5.5, Part B, Attachment 1 – QAPP), the TRV values have not been explicitly identified.

Modification 7-1: NMFS recommends that a table of actual TRV values should be provided.

Without knowing the Toxicity Reference values that the applicant is trying to arrive at (or stay below) the license participants will not be able to interpret model results.

TRVs have not been described or discussed.

The FERC recommendations from their Determination (4/1/2013) have not been followed and therefore the study was not conducted as provided for in the approved plan.

Modification G-1: NMFS recommends that data quality issues and the approach used to resolve data quality issues with suspended solids, holding times and temperatures be described in greater detail in a data quality report.

Data quality issues are not currently described in sufficient detail for NMFS to determine if the study was conducted as provided for in the approved study plan.

Further Comments, Questions and Requests

NMFS did not have the opportunity to develop these into modifications but the study results would have more integrity if these issues were addressed.

Quality Assurance Project Plan (QAPP):

- For the porewater method, it is possible to have a "short circuit" in which surface water (rather than sediment porewater) is extracted by the device. NMFS recommends that AEA comment on and provide more detail on the procedures that are being followed to ensure no short circuiting is taking place during sampling, and how chemistry results are being evaluated to ensure that short circuiting did not occur.
- NMFS recommends that AEA confirm that sediment sample containers were filled entirely (without headspace). The presence of headspace can result in changes to mercury speciation and alter methylmercury levels.
- NMFS recommends that AEA provide additional details about which plant tissues will be collected. Root tissue should be collected in addition to shoots/leaves, as roots can exhibit higher concentrations of mercury compared to other plant tissues (Boening, 2000). Additionally, below-ground plant tissue will be subject to anoxic conditions in sediment following inundation, encouraging the formation of methylmercury.
- NMFS recommends that AEA identify the specific method(s) of fish collection. Details were not provided in the documents on how AEA is capturing fish from the river. The only specification provided was that "Clean nylon nets and polyethylene gloves will be used during fish tissue collection" (D-4, page 1).
- Focusing on the column for "most stringent water quality standards, sediment thresholds and designated uses," NMFS is concerned that the values listed for the following factors are inappropriate:
    - Barium: Should be 3.9 µg/L, based on chronic aquatic life criteria. Source is NOAA SQuiRT, http://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf
    - Beryllium: Should be 0.66 µg/L based on chronic aquatic life criteria. Source is NOAA SQuiRT, http://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf
    - Cobalt: Should be 3.0 µg/L based on chronic aquatic life criteria. Source is NOAA SQuiRT, http://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf
    - Vanadium: Should be 19 µg/L based on chronic aquatic life criteria. Source is NOAA SQuiRT, http://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf

Study Completion Report

(NMFS does not agree that this should have been written, but did still review it.)

- NMFS recommends that providing additional details regarding the criteria that were used to establish acceptable limits for precision between the two analytical laboratories, SGS and ARI, an explanation on how the subset of sites were selected for re-sampling in 2014, and the specific method used to estimate concentration by eliminating interfering elements.
- The document states that there is little difference in physical and chemical conditions between PRM 235.2 and PRM187.2. NMFS questions this conclusion; additional detail needs to be provided on what limits were established to discern whether samples values were similar or different. Also, in 2014, the Watana Dam site was not sampled due to limited accessibility and monitoring occurred several miles downstream. Since this is the proposed location of the dam, NMFS recommends that additional data should be collected from this location.
- The document states that sample results from 2013 showed little horizontal and vertical variability. NMFS disagrees with this conclusion because of the identified data quality issues with the 2013 data, discussed earlier. NMFS also therefore questions AEA's reliance on 2013 results to determine that reduced sample collection efforts were appropriate in 2014.
- The methodology and validity of some of the calculated values in Tables 4.5-3 and 4.5-4 seems questionable. Corrected TP was calculated as -0.065 (Table 4.5-3) and estimate % of TP that is due to TSS was calculated as 128.8%. If there were only one consistent and explainable quality control issue associated with the 2013 data results, the application factor might be appropriate after careful review of the procedure to be used. However, NMFS believes that the issues associated with the 2013 data are multiple and diverse, and therefore the application of the TP Correction Factor was inappropriate.
- NMFS recommends providing additional detail regarding the data quality issues with TSS, holding time and temperature exceedances. The approach has not been sufficiently described, leading NMFS to question the interpretation of the data. NMFS's consultants did not have time to review data reports (field data reports, laboratory data reports) summarizing field data collected during 2013 and 2014 monitoring seasons, and/or conduct any quality control. Thus, NMFS cannot assure data quality provided in the data reports.
- On Page 30, Section 6.1 of the SCR it states "*water quality conditions have not changed over the past approximately 30 years and is typical of water quality*… ." While this statement is true for the majority of the data, there are significant differences in the concentrations of dissolved calcium and magnesium (which increased 1,000 times during summer). NMFS recommends providing an explanation for these differences.

5.6 Water Quality Modeling

ISR Review and Study Modifications

The goal of the Water Quality Modeling Study was to use data from the Baseline Water Quality Study (Section 5.5.) to develop models to evaluate the impacts of the proposed Project on physical parameters within the Susitna River watershed.

Study Objectives

The objectives of the Water Quality Modeling Study, as stated in the Federal Energy Regulatory Commission (FERC) Study Determination (4/1/2013), are as follows:

1. Develop and implement an appropriate reservoir and river water temperature model for use with the past and current monitoring data.
2. Model water quality conditions in the proposed reservoir, including, but not necessarily limited to, water temperature, dissolved oxygen (DO), suspended sediment, turbidity, chlorophyll-a, nutrients, ice (in coordination with Study 7.6 (ice processes)), and metals. (note – this is the wording in the Study Determination, the wording in the Revised Study Plan is different)
3. Model water quality conditions in the Susitna River from the proposed dam site downstream, including, but not necessarily limited to, water temperature, suspended sediment, turbidity, and (in coordination with Study 7.6 (ice processes).

National Marine Fisheries Service (NMFS) Study Modifications

Based on our review, the Alaska Energy Authority (AEA) did not provide sufficient information to reliably assess the proposed modeling approach. Consequently, and as explained in further detail below, NMFS recommends the following Study Modifications:

1-1 Demonstrate how the water quality model integrates with other models.

1-2 Describe the effects of missing or inadequate water quality data on model performance.

2-1 Provide evidence that the use of the 20-layer model (not a 40-layer model) with the bottom layer thickness of 25 meters retains accuracy in predicting thermal stratification in the future reservoir.

3-1 Calibrate and validate the riverine model for the focus areas, and provide summary statistics that quantify model fit.

3-2 Provide "preliminary calibration" results of the water quality model incorporating hydrodynamics, water quality results, model parameterization, and goodness of fit statistics for selected locations, dates, and times.

3-3 Incorporate mercury into the Environmental Fluid Dynamics Code (EFDC) water quality model.

3-4 Explain how the differences in grid resolution between Water Quality and Groundwater models will be resolved while maintaining the accuracy of the data.

3-5 Expand the geographic extent of the water quality modeling studies below project river mile 29.9

Variances from the study plan were not identified by NMFS, however the water quality model is still under development and we anticipate there will be revisions and improvements. Variances in the Baseline Water Quality Study 5.5 will affect the completion of study 5.6 however; those are discussed in our comments on study 5.5, rather than in this section.

Review by Objective

In this section NMFS will evaluate whether each objective has been met, and if not suggest modifications to the work that would allow the objective to be met.

Objective 1: *Develop and Implement an appropriate reservoir and river water temperature model for use with past and current monitoring data.*

This section is well presented by AEA, including the relationship between the Water Quality Model and the Geomorphology Model and the relationship between the Water Quality Model and the River Ice Process Model. However, relationships between these models; and the Groundwater Model and Open Water Flow Routing Model and Ice Cover Model have not been demonstrated to actually work.

The Water Quality Modeling section of the Initial Study Report (ISR) states that the hydrodynamic/water quality model EFDC was selected with three different resolutions including: 3-D Reservoir Water Quality Model, a general 2-D River Water Quality Model, and 2-D River Water Quality Model with Enhanced Resolution Areas. Selection of the EFDC model with its variations fully satisfies Objective a for the Final Study Report (Study Implementation Report) Water Quality Modeling Study, if implemented correctly. The EFDC model is suited for modeling reservoir and riverine environments, and a suite of water quality parameters. Nonetheless, the model does not provide a detailed simulation of ice dynamics and/or groundwater processes. Close coordination with the Ice Modeling and Groundwater Study teams will be required.

The Susitna River water quality model downstream of the proposed reservoir has been developed. The model is designed to simulate temperature, suspended sediment (less than 125 microns), turbidity and ice processes. It is understood that the ice cover and thickness will not be directly simulated in the river, but will instead be provided by the River Ice Process model.

Some modeling results are presented in the Final ISR. The integration of the Water Quality Model with the Groundwater Model assessments is not reported. However, some discussion about integration with the Ice Processes Model was provided.

The ISR report should provide a detailed discussion regarding the integration of the Water Quality Model with the Groundwater Model, Ice Processes Model, Geomorphology Model, and other models and their connection (i.e. which model parameters and results are being transferred from the Water Quality Model). Access to this information is vital to determining how and if the scale and resolution of this information transfer may affect results and conclusions of the overall study.

AEA has not released a summary table of selected EFDC model parameters used in different parts of the model, and state model variables and outputs have been only partially summarized in the ISR, Parts A and B, although they were presented in one of the previous technical meetings.

In addition, it is a standard practice to provide comparison statistics while evaluating how "good" a model is. Although scatter plots of the predicted versus observed temperature were provided for in the April 2014 Proof of Concept analysis (Appendix A, Figures A-4 and A-6), similar graphs are needed for the updated analysis. Please provide a table of calibration statistics (residual average, residual standard deviation, R2, etc.) for selected locations and selected times/dates. It is important to provide this information as early as possible in the process (i.e., not at the end of the study), to provide sufficient time for mitigation measures if the model needs to be corrected.

Modification 1-1: NMFS recommends demonstrating how the water quality model integrates with other models.

This modification will best be accomplished by a New Study for Model Integration. The request for this new study is included in a separate enclosure.

Modification 1-2: NMFS recommends AEA describe the effects of missing or inadequate water quality data on model performance.

It is unclear how the spatial and temporal discontinuities in the data - specifically large gaps between water quality transects - affect the hydrodynamic part of the water quality model. We suggest a longitudinal profile of the model be displayed graphically to evaluate how well the model predicts conditions at locations on the river where there is a greater distance between data collection sites. The specific reach in question is: Reach Project River Mile (PRM) 143.6 – PRM 209.2 (no water temperature data were collected during summer 2013 and winter 2013–2014);

It is unclear whether the study was conducted as provided for in the approved study because license participants do not know whether missing or inadequate data affects the performance of the model, and therefore whether the model used is appropriate for the past and current monitoring data.

Objective 2: *Model water quality conditions in the proposed reservoir, including, but not necessarily limited to, water temperature, DO, suspended sediment, turbidity, chlorophyll-a, nutrients, ice (in coordination with Study 7.6 (ice processes)), and metals.*

The plan for the proposed model grid covering the reservoir appears adequate. However, the model grid in a vertical direction was not illustrated. The proposed thickness of the bottom layer (in the 20-layer vertical grid) is too high (82 feet/25 meters) to accurately capture the reservoir temperature stratification. Results supporting "adequate simulations under ice-free conditions" using the 20-layer and 40-layer configurations should be presented to allow for an appropriate review of the modeling results.

The 3-dimensional model is being developed to simulate the future conditions in the proposed reservoir. The model has been set to simulate temperature, DO, suspended sediment (less than 125 microns), turbidity, chlorophyll-a, nutrients, metals, and ice dynamics. Dissolved oxygen and some nutrients (nitrite plus nitrate, ammonia nitrogen, dissolved and particulate organic phosphorus, dissolved and particulate inorganic phosphorus) are being included as the model state variables. Suspended sediment transport is included in the model through the sediment diagenesis module and through the solids and fate transport module.

An explanation of how chlorophyll-a will be included in the EFDC model has not been provided. The horizontally variable ice cover and thickness will be simulated by the reservoir temperature model. Although the model was calibrated, no results demonstrating success of the calibration have been presented in the report. This validation and calibration information is critical. Although reservoir simulations showing changes in water temperature have been described, simulations for the other variables are missing.

Modification 2-2: NMFS recommends providing evidence that the use of the 20-layer model (not a 40-layer model) with the bottom layer thickness of 25 meters retains sufficient accuracy in predicting thermal stratification in the proposed reservoir.

The study currently uses a 20-layer model.

The approved studies were not conducted with the level of detail provided for in the approved study plan.

Objective 3: *Model water quality conditions in the Susitna River from the proposed dam site downstream, including, but not necessarily limited to, water temperature, suspended sediment, turbidity, and (in coordination with Study 7.6 (ice processes).*

AEA selected EFDC to model water quality in the Susitna River. EFDC may be the most appropriate model, but the implementation, to date, does not leave the license participants with much confidence in the results. The largest issues are the scarcity of data which have been fed into the model and the fact that neither calibration nor validation has been completed.

Modification 3-1: NMFS recommends calibrating and validating the riverine model for the focus areas, and provide summary statistics that quantify model fit.

NMFS cannot accept results generated from models that have not been correctly calibrated and subsequently validated with different data.

The riverine model has not been validated and the model has not been calibrated in the focus areas. The simulation results provided show that the model performs satisfactorily for selected times and locations; however, no model summary statistics were provided to show how these results are spatially representative of the overall model performance. Furthermore, no backup information was provided to complement the riverine model calibration, the model has not been validated, and no model calibration has been conducted for any of the selected focus areas.

The study was not conducted as provided for in the approved study plan because it is not a working model until it has been validated.

Modification 3-2: NMFS recommends providing “preliminary calibration” results of the water quality model incorporating hydrodynamics, water quality results, model parameterization, and goodness of fit statistics for selected locations, dates, and times. Goodness of fit refers to applying the model to known past conditions and seeing how close the modeled water quality parameters are to the same parameters measured in the field.

The proposed configuration grid for the main river stem and tributaries appears reasonable. The results and the material illustrating the preliminary model calibration were not available at the time of this review.

The model should be undergoing calibration using data collected during the June through August 2012 period, however little progress was made on the modeling study in 2015 due to loss of staff on the project. The hydrodynamic module was being calibrated first (to velocities and water levels), followed by the water quality module. The ISR did not disclose details regarding the ongoing calibration efforts. Some riverine model simulation results were provided during the 2014 Proof of Concept Meeting and are described in the ISR report. However, no calibration details have been provided. In addition, only the flow and temperature simulation results were presented. Suspended sediment, turbidity, and metals should also be simulated.

The applicant is required to complete model calibration and validation according to the FERC Study Plan Determination (4/1/2013). AEA committed to release the hydrodynamic calibration report in early 2015. It is unclear whether AEA will be able to split the data set in two parts (one part for calibration, and one part for validation) as required in the Revised Study Plan. Until a satisfactory calibration report has been provided, it is difficult for license participants to have confidence in the results.

The study was not conducted as provided in the approved study plan because “goodness of fit” statistics, which allow the license participants to assess the quality of the model output, are not provided.

Modification 3-3: NMFS recommends incorporating mercury into the EFDC water quality model.

Further details are needed regarding incorporation of the mercury model into the EFDC. This model will be incorporated as a new EFDC module "to simulate mercury cycling and possibly other metal and organic contaminants, if analysis of observational data suggests a need to address this toxicity" (ISR Section 5.6, page 7).

The Final ISR states that the reservoir water quality model and the mercury recycling model will be configured and tested in 2015 and that the downstream water quality model will be configured for pre-and post- project conditions and calibrated for pre-project conditions. Additional calibration is planned for the focus areas. At the time of this submission, this calibration and validation has not occurred.

The plan for conducting the mercury cycling model is not clear. The Final ISR does not provide details regarding the mercury modeling and, to date, details on this modeling effort have not been released. The Final ISR does not provide a schedule for completing the mercury cycling model.

The study was not conducted as provided for in the 5.7 Mercury approved study plan as reviewed in the FERC determination (4/1/13). FERC recommended including mercury in the EFDC model and this has not been done.

Modification 3-4: NMFS recommends explaining how the differences in grid resolution between water quality models and the groundwater models will be resolved while maintaining the accuracy of the data.

Hydrodynamic and temperature modeling results were included in the Final ISR showing that robust modeling can be conducted in Focus Area 128. It is unclear whether the EFDC modeling grid provides adequate accuracy to model lateral habitats. It would be useful if AEA would provide tables identifying grid sizes used in a) the main Susitna River, b) target focus areas – main channels, and c) the target focus areas – lateral side channels and sloughs.

The report states that "anticipated spatial resolution in the focus areas is "…100 meters (m) longitudinally and 30 m laterally." The corresponding grid shown in Figure 5.4-1 appears adequate; however the grid resolution should be scaled to the level of resolution needed to represent groundwater upwelling and ice dynamics in each area. It will be necessary to show how the selection of this particular grid resolution improves the accuracy of capturing groundwater upwelling and the thermal stratification reflected in the thermal image assessment maps. The grid resolution seems to neither match the scale of localized groundwater upwelling nor significant changes in the thermal energy map assessment.

The study was not conducted as provided for in the approved study plan because the grid resolution was not appropriately sized to fit crucial processes like groundwater upwelling and does not match the grids in other studies.

Modification 3-5: NMFS recommends expanding the geographic extent the modeling studies below project river mile 29.9. If EFDC is not appropriate for the highly braided river transitioning into an estuary, then a different modeling technique could be selected and applied.

The Final ISR states that the results of the pre- and post-project EFDC modeling runs will be used to determine whether to extend the Water Quality Modeling study below PRM 29.9. Prior to finalizing this decision, an assessment of how the EFDC model will be used to represent a multiple braided river is required.

The water quality model, EFDC, has been developed from the Susitna reservoir to the Susitna River PRM 29.9 downstream. The extension of the EFDC model in the Susitna River downstream of PRM 29.9 would significantly increase complexity (because of a multiple braided river), and would require collection of detailed bathymetry to establish a solid hydraulic, geomorphologic, and water quality database. Simplified studies were conducted in off-channel areas in downstream reaches below PRM 29.9. The approach could be simplified by using the EFDC model, open water model, and the PHABSIM (Physical Habitat Simulation) model during the ice-free period as needed to assess project-related impacts in this downstream reach. Relationships to the other suite of project models (groundwater and geomorphology) could be utilized only if the data are available.

The study was not conducted as provided for in the approved study plan because the decision to not include the lowest 29.9 miles of river was made before the EFDC model was completely functioning and before model results were presented to the license participants.

References

Ji, Zhen-Gang et al., 2002. “Sediment and Metals Modeling in Shallow River”, Journal of Environmental Engineering, DOI: 10.1061/(ASCE)0733-9372(2002)128:2~105.

US Army Corps of Engineers, Savannah District, Environmental Impact Statement. 2012. Appendix : Cumulative Impact Analysis, Savannah Harbor Expansion Project, Chatham County, Georgia and Jasper County, South Carolina, January 2012

5.7 Mercury Assessment and Potential for Bioaccumulation

ISR Review and Study Modifications

The following comments and modifications represent current and outstanding comments that have not been addressed by the Alaska Energy Authority (AEA), or the Federal Energy Regulatory Commission (FERC). The services contractors reviewed of the technical memoranda, meeting summaries, and meeting comments related to 5.7 since AEA released the Final Initial Study Report (ISR) on June 3, 2014 (10 documents). Since the ISR was issued, AEA has released or presented additional study plan information and errata including (partial list):

- 2014 Study Season Technical Memoranda, September 30, 2014
- ISR Meeting Presentation Materials, October 16, 2014
- Errata Release & Additional 2013 Sampling Data, November 14, 2014
- Updated Quality Assurance Project Plan (QAPP), of Study 5.5, June 2014
- Part D: Supplemental Information to June 2014 Initial Study Report, November 2015
- Study Implementation Report (SIR), November 2015
- Appendix A: Mercury Assessment Pathways Analysis Technical Memorandum, October 2015

The following comments are therefore focused on 2013 study plan reports and metadata results. The National Marine Fisheries Service's (NMFS) contractors did not have sufficient time or resources to thoroughly review documents from 2014, and even less time to look at the actual data for water chemistry or quality control documents for these data.

Study Objectives

The objectives of the Mercury Assessment and Potential for Bioaccumulation Study, as specified in FERC Study Determination (4/1/2013), are to:

1. Summarize available and historic water quality information for the Susitna River basin, including data collection from the 1980s Alaska Power Authority (APA) Susitna Hydroelectric Project.
2. Characterize the baseline mercury concentrations of the Susitna River and tributaries. This will include collection and analyses of vegetation, soil, water, sediment pore water, sediment, piscivorous birds and mammals, and fish tissue samples for mercury.
3. Use available geologic information to determine if a mineralogical source of mercury exists within the inundation area.
4. Map mercury concentrations of soils and vegetation within the proposed inundation area. This information will be used to develop maps of where mercury methylation may occur.
5. Use the water quality model to predict where in the reservoir conditions (pH, dissolved oxygen, turnover) are likely to be conducive to methylmercury formation.
6. Use modeling to estimate methylmercury concentrations in fish post-project over time.
7. Assess potential pathways for methylmercury to migrate to the surrounding environment.

8. Coordinate study results with other study areas, including fish, instream flow, and other piscivorous bird and mammal studies.

FERC approved the above objectives, but also recommended changes in their Study Plan Determination (4/1/2013) specifically:

9. Use of the Harris and Hutchinson and Environmental Fluid Dynamics Code (EFDC) Models for Mercury Estimation: FERC recommended that AEA use the more sophisticated Phosphorus Release Model to predict peak methylmercury levels in fish tissue, regardless of the outcome of the other two models.
10. Mercury Effects on Riverine Receptors: FERC recommended that AEA include likely riverine receptors (i.e., biota living downstream of the reservoir that may be exposed to elevated methyl mercury concentrations produced in the reservoir and discharged to the river) as part of the predictive risk analysis. The additional study element would have a low cost (section 5.9(b)(7)) because AEA would simply add consideration of additional receptors to the existing analysis. This information is necessary to evaluate potential project effects downstream of the reservoir (section 5.9 (b)(5)).

NMFS Study Modifications

Based on the March 2016 ISR meeting and to meet the overall mercury assessment study goals, the NMFS recommends the following modifications:

2-1 Conduct a replacement year of field sampling due to invalidity of the 2013 data set.

2-2 Analyze entire fish for mercury rather than specific muscle tissues, as birds and larger fish do not fillet their fish before consuming them.

2-3 Collect mercury samples from fish to document baseline mercury concentrations and arrive at the Revised Study Plan (RSP) sample size of 10 fish per species.

3-1 Map mercury concentration data collected from stationary sources, such as native soils and vegetation and investigate any hotspots.

6-1 Complete all elements set forth in the SIR including the phosphorus release modeling and the measurement of mercury in biota pre-project, and modeling of mercury concentrations in fish and piscivorous wildlife (including Beluga) over time post-impoundment be completed.

7-1 Conduct the Mercury Assessment Pathways Analysis as set forth in the SIR. It should be noted that the pathway analysis should not preclude collection of baseline data to meet the FERC approved study plan objectives.

10-1 Analyze the mercury pathways to quantify the possibility that mercury will bio-accumulate to toxic levels in Cook Inlet beluga whales (CIBW) as they are a federally listed species. Since NMFS does not want CIBW approached or sampled, alternative means would need to be investigated.

AEA Proposed Modifications

The following modifications proposed by the AEA represent areas of disagreement.

- AEA has requested that the limited sampling of fish performed to date be considered adequate. NMFS does not agree with this (See modification 2-4).
- Mercury samples in 2013 were either rejected by the laboratory or had significant quality control issues. AEA proposes to apply a total phosphorous (TP) correction factor to these data, suggesting that will make them usable for the water quality modeling and the pathways analysis.
    - NMFS maintains that use of the correction factor is not appropriate in this case. Sampling for mercury should ultimately provide at least two years of representative data to document baseline. The use of a data correction factor is not appropriate given the additional issues associated with the 2013 data. There were numerous other problems in the QA/QC control (field or method blank data contamination, bottle, or suspect bottle contamination, and/or preservative contamination, failure to meet specified holding times), so the TP correction factor should not have been used.

AEA stated in the Final Study Plan (FSP) that FERC modifications to the RSP will be provided in the Quality Assurance Plan and Protocol (QAPP) and that "the information in the QAPP will supersede relevant details in the FSP" (page 5.5-1). AEA has provided an updated QAPP for the water quality and mercury assessment as Attachment 1 to Section 5.5, Part B, provided in June 2014. Updates to the QAPP have been considered in the review of Section 5.7, Parts B and C, where relevant.

Review by Objective

Objective 1: *Summarize available and historic water quality information for the Susitna River basin, including data collection from the 1980s Alaska Power Authority (APA) Susitna Hydroelectric Project.*

Both historic and literature data were reviewed to summarize the current understanding on the occurrence of mercury in the environment. These were included in the RSP and repeated in the ISR (June, 2014), and summarized in the SIR. Sources included information developed by the AEA Susitna Hydropower Project, state and federal agencies and the published scientific literature.

No modifications are recommended to Objective 1.

Objective 2: *Characterize the baseline mercury concentrations of the Susitna River and tributaries. This will include collection and analyses of vegetation, soil, water, sediment pore water, sediment, piscivorous birds and mammals, and fish tissues for mercury.*

Water Sampling

In 2014, both baseline and focus area water quality sampling were conducted. For the baseline effort, water quality samples were collected on an average of five mile intervals, with a total of 18 locations in 2013. Samples were collected at each baseline sampling location near the right and left banks and mid-stream locations from a depth of 0.5 meters below the surface and 0.5 meters above the bottom.

For Study 5.7, grab samples were analyzed for total and dissolved mercury. Laboratory quality control samples included duplicate samples between laboratories. Spiked and blank samples were prepared and processed by the laboratory. The Focus Area Sampling Protocols differed from the baseline sample locations in that they have a greater density of locations, with transects spaced every 100 m to 500 m and water quality samples collected at three or more locations along each transect.

Water were analyzed for mercury (total and dissolved) and methylmercury utilizing Environmental Protection Agency (EPA) Methods 1631E and 1630. The laboratory attained method detection limits specified in the QAPP that were at the applicable regulatory criteria and provided all laboratory QA/QC documentation. Additional details of the sampling methods were provided in the updated QAPP.

In a variance from the FSP, water samples intended to be collected from PRM 225.5 were instead collected at PRM 235.2 due to limited access to the original site by helicopter. Similarly, water samples from PRM 235.2 (Susitna River adjacent to Oshetna Creek) and 187.2 (Susitna at Watana Dam) were collected from just one position in the river due to limited access when wading. The ISR stated that there are no known influences to water quality between the proposed monitoring sites and those that were sampled.

Vegetation

Vegetation samples were collected from ten different sites within the proposed inundation area in 2013. No results for mercury levels were reported in the ISR, although some raw data is available for review in laboratory reports attached to the data validation reports posted to the http://gis.suhydro.org/reports/isr website. It was not feasible to fully evaluate the data at this time due to the lack of metadata (e.g., sample geospatial information, sample details). NMFS recommends that the vegetation metadata be provided, in addition to the time and resources to review it. These data are an important part of the post-Project (i.e., with Project) mercury modeling effort.

The sampling was biased toward vegetative mass, that is to say species that were present in the inundation area at low frequency and size were not sampled, because even if these plants contain mercury, their contributions to mercury methylation will be low. This sampling approach is consistent with the study goals of collecting representative data on concentrations of mercury in the dominant vegetation in the inundated area.

No variances were reported for the collection of vegetation, with a total of 50 vegetation samples collected from plants at five sites in each of ten locations within the proposed inundation zone in August 2013. The sampling was biased toward plants with the largest vegetative mass at most sites. Plant samples were analyzed for total and methyl mercury per EPA Methods 1631 and 1630, respectively.

Soil

All planned soil samples were collected in 2013, consisting of a combination of surface moss, peat, and mineral soils. A general observation was provided that a significant fraction of organic matter (moss and peat) overlays the mineral soil at each sample location, with this material likely being the primary potential source of mercury methylation in the future reservoir. No results for soil sample mercury levels were reported in the ISR, although some raw data is available for review in laboratory reports attached to the data validation reports posted to the http://gis.suhydro.org/reports/isr website. It was not feasible to fully evaluate the data at this time due to the lack of metadata (i.e., sample geospatial information, sample details, etc.). However, both mercury and methylmercury were detected in soil samples.

Each soil sample was split and digested using two methods in the laboratory analysis to ensure that the presence of high organic matter (peat) did not underrepresent the amount of mercury in each sample. In Part B of 5.7, AEA notes that EPA recommends digestion with HNO_3/H_2SO_4 before using BrCl with organic soils. It is not possible at this time to evaluate the differences in results obtained from the two extraction methods because a data summary is not provided.

In a variance from the RSP, two digestion methods were used in the preparation of soil samples for mercury analysis due to the large proportion of peat present in the soil samples. A total of 50 soil samples were collected at each of the vegetation sampling sites in the inundation zone during August 2013. Samples were analyzed for total mercury and methylmercury using EPA Methods 1631 and 1630, respectively, and the results reported as both wet (ww) and dry (dw) weight.

Sediment and Sediment Porewater

Sediment and sediment porewater samples were collected in the mainstem Susitna River near the mouths of the following tributaries: Jay, Kosina, and Goose Creeks, and the Oshetna River (downstream of islands), and in similar riverine locations. Sediment porewater was collected from the sites listed above and separated from sediments in the field laboratory using a pump apparatus, and filtered with a 0.45-µm pore size filter in both the lab apparatus and field apparatus. Samples were analyzed for total mercury by EPA Method 1631E. In addition, sediment size and total organic carbon were analyzed to evaluate whether these parameters are predictors for elevated mercury concentrations.

Sediment samples were analyzed from 10 sites for metals, sediment grain size, total solids, and with the additional parameters of pH, temperature, hardness, alkalinity, total organic carbon and dissolved organic carbon for sediment porewater. Four samples were collected in 2013 and six in 2014.

Additionally, sediment samples were collected using hand augers or stainless steel spoons in a variance (the FSP stated use of an Ekman dredge or a modified Van Veen grab sampler), and followed the Clean Hands/Dirty Hands sampling method identified in Objective f of Section 5.5. All 2014 sediment samples were collected using these methods.

Modification 2-1: NMFS recommends that a replacement year of field sampling be completed due to invalidity of the 2013 data set.

We have indicated in previous memoranda that the 2013 mercury data were of inadequate quality and are inappropriate for use in characterizing pre-project baseline. Since NMFS request for a comprehensive summary of the analytical issues encountered and how these issues were addressed as not been provided, the 2013 samples should be recollected and the new samples analyzed.

The study was not conducted as provided for in the approved study plan because the data analysis did not follow standard lab protocols and QAQC standards were not met.

Modification 2-2: NMFS recommends that entire fish should be analyzed for mercury rather than specific muscle tissues**.** Telflon sheets rather than polyurethane are important.

Neither birds nor larger fish fillet smaller fish before consuming, so choosing to sample only fish fillets to analyze for mercury may not correctly represent the bioaccumulation of mercury.

The study was not conducted as provided for in the study plan because the method of sampling muscle tissue and using polyurethane sheets could bias the data.

Modification 2-3: NMFS recommends that additional fish be collected and sampled to document baseline mercury concentrations and arrive at the RSP sample size of 10 fish per species.

Not all targeted fish species were collected in the study area during 2013, and the effort was discontinued in 2014.

Target Species	Number collected in 2013	Otoliths Collected?
Lake Trout	7	Yes
Longnose Sucker	7	Yes
Dolly Varden	7	Yes
Arctic Grayling	16	No
Burbot	8	Yes
Slimy Sculpin	7	No
Whitefish	1 – Humpback 2 – unidentified 10 – round	Yes

No mercury or methylmercury tissue concentrations were reported in the ISR, although some raw data is available for review in laboratory reports attached to the data validation reports posted to the http://gis.suhydro.org/reports/isr website. It was not feasible to fully evaluate the data at this time due to the lack of metadata (i.e., sample geospatial information, sample details, etc.). However, both mercury and methylmercury were detected in fish tissue samples. Due to lack of metadata, it was not possible to discern which results were for liver and which results were for filets.

While the RSP targeted the collection of seven to ten fish of each target species, additional fish were collected for Arctic Grayling (16) and Round Whitefish (12), including the incidental collection of some juvenile fish (also in variance with the RSP stated intent of only collecting adult fish). NMFS recommends that future sampling be collected as defined in the RSP.

In contrast, Slimy Sculpin, a non-target species, were observed in large numbers in the study area, and were collected for analysis of whole body samples (due to their small size) to expand the amount of data available for mercury bioaccumulation. Slimy sculpin were chosen as an alternative species. Because Humpback Whitefish were rare and Rainbow Trout were not found in the inundation area, this alternative species was chosen. AEA should describe the difference in feeding behavior between target species and Slimy Sculpin and the overall implications for pathway analysis.

Otoliths could not be extracted for all fish. Only 21 fish have had otoliths extracted and analyzed for age as part of this study to date. The determination of sex and sexual maturity of fish proved to be problematic in the field, and the sex of only 12 fish was determined.

The project QAPP stated that Teflon sheets would be used for the fish when placed in the sample bag. The study team had difficulty sourcing this material, and switched to polyethylene sheets. Given that muscle samples are taken from inside the fish, this material should not have introduced any contamination to the sample and have no effect on achievement of the study objectives.

The study was not conducted as provided for in the approved study plan because methods were modified and only fillets were tested for mercury.

Objective 3: *Utilize available geologic information to determine if a mineralogical source of mercury exists within the inundation area.*

Co-occurrence of elevated mercury concentrations in multiple samples may indicate a mercury hotspot or area of concern. Such hotspots would need to be evaluated explicitly in future modeling or risk estimation exercises, as they may result in localized post-project mercury risks. The presentation of the data is insufficient for a full understanding of mercury conditions in the project area, because simple averages obscure the spatial patterns. This is a situation where the variance is more important than the mean. Mercury concentrations range over two orders of magnitude, with maximum values for fish, sediment, and water that exceed the screening criteria.

Because of the exceedances and wide variability in the data, it may not be appropriate to treat the project area as a simple homogenous unit. The raw data should be mapped as well as shared in tables and figures that describe the range in concentrations, as well as measures of central tendency. Percentiles are often used to describe non-normally distributed environmental data. No variances were identified in the methodology section of the ISR concerning the methods used to determine if a mineralogical source of mercury exists within the inundation area.

Modification 3-1: NMFS recommends mercury concentration data collected from stationary sources, such as native soils and vegetation, should be mapped and hot spots should be investigated. Protocols for these location specific investigations should be developed.

Hot spots of mercury do occur in nature; however, these could be contained if one knew where they were located prior to filling the reservoir.

The current study proposed to submit the data in tables and there is no provision for follow-up work if hot spots are detected.

The study has not yet been conducted as provided for in the approved study plan.

Objective 4: *Map mercury concentrations of soils and vegetation within the proposed inundation area. This information will be used to develop maps of where mercury methylation may occur.*

To our knowledge this task has not been completed. NMFS suggests no modifications at this time.

Objective 5: *Use the water quality model to predict where in the reservoir conditions (pH, dissolved oxygen, turnover) are likely to be conducive to methylmercury formation.*

To our knowledge this task has not been completed. NMFS suggests no modifications at this time.

Objective 6: *Use modeling to estimate methylmercury concentrations in fish post-project over time.*

Modification 6-1: NMFS recommends all elements set forth in the SIR including the phosphorus release modeling and modeling of mercury concentrations in fish and piscivorous wildlife (including Beluga) over time post-impoundment be completed.

Prediction of projected potential mercury concentrations in fish (using the phosphorus release model) has not yet been completed. The applicant has provided additional information related to the inputs to the Harris and Hutchinson model. These data have not been reviewed, and additional comments may be provided.

To date the study is not finished which means it was not conducted as provided for in the approved study plan.

Objective 7: *Assess potential pathways for methylmercury to migrate to the surrounding environment.*

Modification 7-1: NMFS recommends that a Mercury Assessment Pathways Analysis as set forth in the SIR be conducted. It should be noted that the pathway analysis should not preclude collection of baseline data to meet the FERC approved study plan objectives.

At the time of this review, the AEA modeling team did not provide enough information to allow an assessment of methylmercury modeling results. AEA needs to define the procedure to be used in their development of the Mercury Pathway Analysis and what the ultimate purpose of the analysis is. AEA has indicated that the mercury pathway analysis will drive decisions, including whether to continue mercury data collection as described in the FERC-approved Study Plan. Additional supporting information is needed to show the validity of the Mercury Assessment Pathways Analysis. For example, (a) Consideration of suspended solids to promote mercury bioavailability in surface water and (b) More complete description on the subset of metals selected for pathway analysis should include description of the concentration of metals found in the baseline sampling effort. AEA should provide details in the potential pathways for methylmercury to migrate to the surrounding environment, and provide an expanded literature survey on these pathways to ensure applicability to the conditions expected in the future impoundment.

The approved study was not conducted as provided for in the approved study plan.

Objective 8: *Coordinate study results with other study areas, including fish, instream flow, and other piscivorous bird and mammal studies.*

This objective will be best addressed through a new study for Model Integration. NMFS has included a new study request for model integration as a separate enclosure.

Objective 9: *Use of the Harris and Hutchinson and Environmental Fluid Dynamics Code (EFDC) Models for Mercury Estimation: FERC recommended that AEA use the more sophisticated Phosphorus Release Model to predict peak methylmercury levels in fish tissue, regardless of the outcome of the other two models.*

To our knowledge, this task has not been completed.

Objective 10: *Mercury Effects on Riverine Receptors: FERC recommended that AEA include likely riverine receptors (i.e., biota living downstream of the reservoir that may be exposed to elevated methyl mercury concentrations produced in the reservoir and discharged to the river) as part of the predictive risk analysis.*

Modification 10-1: NMFS would particularly like the mercury pathways analysis to quantify the possibility that mercury will bio-accumulate to toxic levels in Cook Inlet beluga whales (CIBW) as they are a federally listed species. Since NMFS does not want CIBW approached or sampled alternative means should be investigated.

These whales live from 30-40 years and mercury bioaccumulation has already been found in some individuals. Even a small increase in mercury in prey species could significantly elevate levels found in CIBW.

The study was not conducted as provided for in FERC determination (4/1/2013) for the approved study plan as the highest organism in the food chain has not been focused on.

Recommendations that NMFS did not have the time to develop into modifications follow:

- At the dam structure location water quality samples should be taken from both banks and the center.
- Using a single soil digestion method be used for samples is the preferred scientific method. Since the data has been collected we suggest the applicant apply both methods to a five equally split samples and present how much they vary.

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6.5 Geomorphology

ISR Review and Study Modifications

The National Marine Fisheries Service's (NMFS) review of Geomorphology (study 6.5) is a compilation of previous document reviews that were prepared by the Alaska Energy Authority (AEA). The reports, technical memoranda (TM) and meeting presentations include (partial list):

- Revised Study Plan (RSP), December 2012;
- Final Initial Study Report (ISR), June 2014 & ISR Meeting, October 2014;
- Mapping of Geomorphic Features and Turnover within the Middle and Lower Susitna River Segments form 1950s, 1980s and Current Aerials, technical memorandum, Sept. 2014;
- 2014 Update of Sediment Transport Relationships and a Revised Sediment Balance for the Middle and Lower Susitna River Segments technical memorandum, September 2014;
- Historical Cross Section Comparison (1980s to Current) technical memorandum, September 2014;
- Assessment of the Potential for Changes in Sediment Delivery due to Glacier Surges technical memorandum, November 2014;
- Winter Sampling Technical Memorandum (WSTM)
- Literature Review- Dam Effects on Downstream Channel and Floodplain Geomorphology and Riparian Plant Communities and Ecosystems, November 2014; and
- Team meeting, Presentation of "Assessment of the Potential for Changes in Sediment Delivery due to Glacier Surges," December 5, 2014.

The geomorphology investigation includes two studies (Study 6.5 and Study 6.6). Based on NMFS's understanding of the Revised Study Plan (RSP), the Geomorphology Study Section 6.5 investigates the historical and current geomorphology and geomorphic/geologic controls of the Susitna River and is expected to identify historic changes in morphology over time along the Susitna River and key physical processes governing the behavior of the river. The data collection varied from exceptional (main channel pebble counts) to not complete (sediment supply from tributaries). Some modifications to data collection efforts are listed below.

The 6.5 study did not yet use the past data to identify trends or qualitatively predict the project effects. NMFS expected that these qualitative projections in 6.5, could be used as a check of the geomorphic modeling results presented in 6.6.

The Fluvial Geomorphology Modeling Study 6.6 (reviewed separately) will apply 1-D and 2-D bed evolution models to further quantify geomorphic processes in the existing river, the equilibrium status of identified reaches, and potential project effects on river geomorphology.

Study Objectives

The Geomorphology Study (6.5) objectives as stated in FERC Study Plan Determination (4/1/2013) were:

1. Geomorphically characterize project-affected river channels and floodplains by delineating reaches and mapping geologic and geomorphic features from the proposed dam site downstream to Cook Inlet and from the dam site upstream to the Maclaren River confluence (including the reservoir inundation zone).
2. Collect flow, suspended sediment, and bedload data to support characterization of sediment supply and transport in the Susitna River from Project River Mile (PRM) 84 (Sunshine Station) upstream to PRM 182 (Tsusena Gage) and the Chulitna and Talkeetna Rivers near their confluences with the Susitna River.
3. Determine sediment supply, bed mobilization, sediment transport, and mass balance in the Middle River and Lower River segments between the proposed dam site and downstream to the Susitna Station gage, including the mainstem Susitna River and its tributaries.
4. Assess geomorphic stability and change in the Middle River and Lower River segments by comparing existing geomorphic mapping with geomorphic feature data from historical aerial photography.
5. Characterize surface area versus flow relationships for riverine macrohabitat types over a range of flows in the Middle River segment from the three rivers confluence area upstream to the dam site using information mapped and digitized from aerial photography.
6. Conduct a reconnaissance-level geomorphic assessment of potential project effects on the Lower River segment and Middle River segment considering stream flow, sediment supply and transport, and conceptual frameworks for geomorphic reach response (Grant et al., 2003; Germanoski, 1989).
7. Characterize surface area versus flow relationships for riverine macrohabitat types in the Lower River segment between the Yentna River confluence (PRM 28.5) and Talkeetna (PRM 98.5). The task includes conducting analyses contingent on a determination that (1) a comparison of riverine habitat in the Lower River segment under pre- and post-project flows is warranted for additional flow conditions and (2) aquatic resource studies need to be continued downstream in the Lower River segment.
8. Characterize geomorphology within the proposed reservoir area and assess reservoir trap efficiency, sediment accumulation rates, delta formation, and erosion and mass wasting potential within the reservoir fluctuation zone and shoreline up to 100 vertical feet above the proposed full-pool elevation.
9. Assess large woody debris transport, recruitment, and influence on geomorphic forms in the Susitna River between the mouth and the Maclaren River using recent and historic aerial photography and field studies.
10. Characterize geomorphic conditions (i.e., channel morphology and sediment dynamics, channel migration zone, large woody debris transport, and erosion and sediment delivery) at stream crossings along access roads and transmission line alignments using data obtained from existing sources and field assessment.
11. Integrate the study with Study 6.6 (Fluvial Geomorphology Modeling).

FERC approved the above objectives without recommending any modifications.

NMFS Study Modifications

To fulfill the goals of the Geomorphology Study (6.5) and be able to differentiate between natural change and project-induced change, NMFS poses the following question which is essential to evaluating the project's effects on geomorphology and is germane to both 6.5 and 6.6.

- Does AEA intend to use existing conditions to represent the future without project effects?
  - If AEA does not intend to use existing conditions to represent the future without the project, NMFS requests:
    - A detailed explanation of predicted changes in channel morphology over the next 100 years, and;
    - An evaluation of the uncertainty of the predictions of change.

In order to meet the 6.5 study objectives and as a result of the March 2016 ISR meeting, NMFS recommends the following modifications:

1-1 Characterize the geomorphology of the watershed as a whole and its Middle River tributaries in relation to the present and expected future sediment yield.

2-1 Provide an assessment of uncertainty in the suspended load and bed load estimates for both reported daily values as well as annual load estimates. This may require conducting additional suspended load and bed load measurements to help define the variability of sediment transport rates at a station over time.

3-1 Clarify which size classes of sediments are considered to be supply-limited in the context of this river system and what is meant by sediment transport equilibrium.

3-2 Assess the feasibility of using a morphological approach to estimate long-term bed load transport rates along the Middle and Lower Reaches to provide an independent check on the short-term measurements from samplers.

3-3 Use Information from the 7.7 Glacier and Runoff Study to help predict changes in sediment supply. Substantial modifications to study 7.7 have been requested.

5-1 Take aerial photos to document the rivers lateral extent in the middle river at the range of flows that AEA intends discharge from the dam. To date the photos are at a single flow, 12,500 cfs.

6-1 Conduct the literature review in the manner of Kellerhals and Gill (1973) to provide case histories and experience related to downstream effects of dams in northern climates. This information should assist in defining potential effects on the Susitna River.

6-2 Use a range of methods gleaned from the literature review, case histories from past projects, and site specific analysis to provide reconnaissance level assessment of project impacts.

7-1 Take aerial photos from the Yenta Confluence to Talkeetna to document the rivers lateral extent at the range of flows that are likely post project. To date the photos are at a single flow, 12,500 cfs.

11-1 Utilize information from study 6.5 to test and validate the accuracy of long-term (decadal) predictions from the numerical models and utilize geomorphic methods to make predictions of channel response to changes in sediment supply and discharge so as to provide independent checks on the model predictions.

11-2 Provide details about how the lateral channel changes along the Middle River will be predicted if the effective discharge calculation is abandoned.

Review by Objective

Objective 1: *Geomorphically characterize project-affected river channels and floodplains by delineating reaches and mapping geologic and geomorphic features from the proposed dam site downstream to Cook Inlet and from the dam site upstream to the Maclaren River confluence (including the reservoir inundation zone).*

Modification 1-1: NMFS recommends characterizing the geomorphology of the watershed as a whole beyond the river valley bottom and evaluating the Middle River tributaries in relation to the present and expected future sediment yield.

A description of the basin and its major tributaries in terms of physiography, geology, climate, hydrology, land use, mass wasting processes and sediment sources are basic to understanding the factors that govern the morphology and sediment transport characteristics of a river.

The work to date provides a description of the geomorphology of the Susitna River and describes geologic features on the valley floor that affect local channel morphology. The assessment does not include any characterization of watershed-scale processes in the basin or the major tributaries, particularly information on variations in watershed sediment sources and sediment supply. This omission makes it difficult to interpret morphological changes along the mainstem of the river.

The studies were not conducted as provided for in the approved study plan because the characterization of the geomorphology of the tributaries was not completed.

Objective 2: *Collect flow, suspended sediment, and bedload data to support characterization of sediment supply and transport in the Susitna River from PRM 84 (Sunshine Station) upstream to PRM 182 (Tsusena Gage) and the Chulitna and Talkeetna Rivers near their confluences with the Susitna River.*

The final study plan indicated that bed load measurements would be collected at the gage "Susitna River above Tsusena Creek" (Study Plan RSP Section 6.5.4.2.2). The ISR indicated measurements were conducted on only five dates in 2012 and the program was subsequently terminated. The ISR stated that alternate means would be used to determine the bed load passing the dam site. In particular, it was proposed to utilize data from the Gold Creek gage, since there is only a 20% difference in drainage area between the two gages. However, Table 4-2.3 of the ISR indicated no bed load data were collected in 2012-2013 at the Gold Creek gage. Therefore, information on bed load transport rates at the dam site will be limited to data from previous studies in the 1980s. If data from the 1980s and 2012-2013 are combined, the consistency of the rating curves needs to be confirmed. Since this location represents a key boundary condition for establishing the sediment balance and sediment transport modeling, this could represent a significant limitation to the study.

Modification 2-1: NMFS recommends an assessment of uncertainty in the suspended load and bed load estimates for both reported daily values as well as annual load estimates. This may require conducting additional suspended load and bed load measurements to help define the variability of sediment transport rates at a station over time.

Information on the amount of sediment moving past the proposed dam site is required in order to assess potential downstream effects from the dam and rates of infilling in the reservoir. The sediment load has been estimated by AEA using Helley-Smith bed load samples and P61 suspended sediment samples. Only very limited sampling was carried out in this study; most of the data were collected during previous studies in the 1980s (Knott et al. 1987). Based on the methods described, the sampling program is expected to be subject to at least two biases.

A P61 suspended sediment sampler was used at the centroid of the flow, rather than a depth integrated sampler, or a P61 at multiple depths and verticals. We expect the majority of the sand load will move in the lower portion of the profile, possibly resulting in under-estimation of the very coarse sand, coarse sand and most of the medium sand. On account of the changes in channel hydraulics and bed texture down river, it is not possible to simply assume the bias introduced is the same at all stations. The shear velocity is anticipated to decrease downriver and as a result, the suspended sediment profile will also change down river.

Helley-Smith samples are known to have variable sampling efficiencies. At no point in the current work, or the 1980's reports, is the efficiency of the sampler mentioned. Based on the bed material grain size data, stones on the bed larger than the opening of the Helley-Smith are present, and are presumably mobile during some portion of the year. No discussions of this problem or potential solutions are provided. It cannot simply be assumed that the bias will be consistent at all of the sites, as the sites have different bed material grain size and the bed load grain size becomes finer farther down river. The issue of temporal variability of bed load transport rates is also not discussed. It is necessary to collect a significant number of samples under steady conditions in order to define accurate mean bed load rates for different flow strengths, and to assess the error around the load estimates due to the bed load temporal variability (Vericat et al, 2006).

AEA referred to the Middle Susitna River as 'sand-dominated', although the bed is made of gravel/cobble with a median size of 100 mm. They showed measurements indicating that 99% of sediment transported is sand. However, US Fish and Wildlife Service mentioned that some bedload measurement equipment, such as a Helley-Smith sampler which has a 75 mm opening, will not capture (and measure) large sediment sizes. Also, that although gravel transport may be relatively low, gravel can transfer between bars. Since gravel is the fraction that makes up the bed, it is the most important from both geomorphology and fish habitat standpoints.

To model the sediment transport behavior, a relatively detailed description of observed transport dynamics is critical. For example:

- Does the grain size of the bed load change on the rising and falling limb?
- At what flow does equal mobility start to occur?
- In the gravel bed reaches, are there areas of pure sand, strips of sand, or only extensive gravel deposits? If strips of sand, or pure sand, does this change seasonally?
- Across the channel does the bed load grain size change? Does it correspond with the local bed material?

To better assess the implications of the observed variability, one approach would be to fit upper and lower envelopes by eye to the rating curves. These relations could then be used in the sediment balance assessment to illustrate the precision of the differences between stations. In particular, the lower bound from the middle reach should be used along with the upper bounds from the lower reach sites to assess the minimum contribution from the area upstream of the proposed dam. Likewise, the upper bound from the middle reach should be used along with the lower bounds from the lower reach sites to assess the maximum contribution from the area upstream of the proposed dam. The sediment budget results need to be presented along with an assessment of the uncertainty of the approach, and this provides one potential mechanism.

More consideration should be given to the underlying uncertainties in predictions and how uncertainty can be accounted for in the studies, since this affects the robustness of the results and confidence in the decisions that are based on the results. This issue is increasingly a significant concern in many earth science studies (Caers, 2011) and among modelers (Cunge, 2008).

The studies were not conducted as provided for in the approved study plan because no measures of uncertainty were presented for the sediment load.

Objective 3: *Determine sediment supply, bed mobilization, sediment transport, and mass balance in the Middle River and Lower River segments between the proposed dam site and downstream to the Susitna Station gage, including the mainstem Susitna River and its tributaries.*

Modification 3-1: NMFS recommends clarifying which size classes of sediments are considered to be supply-limited in the context of this river system and what is meant by sediment transport equilibrium.

Various sediment size classes stop moving down a river either because there is no source (supply), or the flows are not powerful enough to transport them. If the dam is not built, which sizes of sediment will not be present because they are not being supplied by the upstream river, the tributaries, or landslides? Conceptually, without models, what size classes would we expect to be supply limited with the dam (see further discussion under modification 3-2)? The presentation to date implies there is plenty of every size class in the Middle River. Whether that size class moves is a function of only hydraulics or more specifically channel form and discharge.

The approved study was not conducted as provided for in the approved study plan as sediment supply was not fully investigated.

Modification 3-2: NMFS recommends an assessment of the feasibility of using a morphological approach to estimate long-term bed load transport rates along the Middle and Lower Reaches to provide an independent check on the short-term measurements from samplers.

The ISR states, in Section 4.3.2.1, the reach is in sediment transport equilibrium for coarse load (gravel and cobble). Transport equilibrium is not defined in the ISR but we assume this means the coarse fraction of the sediment load is governed by hydraulic conditions, not sediment supply. However, on many gravel-bed rivers, bed load is often governed by both hydraulic conditions and supply: At intermediate flows, transport rates may be governed by the state of the bed (imbrication/paving, armoring) and local influx of loose, unsorted materials introduced by bank collapse and local erosion processes. At higher flows, the surface may become fully mobilized so that transport rates are governed more by hydraulic conditions.

Knott et al. (1987, page 13) reports that the bed load transport follows a cyclical pattern with much more occurring on the rising limb than falling limb. Knott et al. (1987) emphasize the seasonal pattern of transport, and how at high discharge sand and gravel bed load appears to be supply limited. This observation should be the focus of the current studies as more information about the hysteresis is needed to adequately characterize the total load.

Sediment transport that is supply limited is usually associated with wash load, while sediment that is governed by hydraulic conditions is associated with bed material load. The report doesn't explicitly define wash/bed material load in this relatively coarse sedimentary system. The tabulated results generally report suspended sediment coarser than 0.063 mm as bed material load, which is a common assumption on sand-bed rivers but is not necessarily valid on steep gravel/cobble rivers where much of the suspended sand load is basically wash load. However, in the first paragraph of 4.3.2.1 the report states the river was sediment supply limited for the finer (sand and wash load) size fractions. If the sand component is supply limited (which seems reasonable especially for the 0.063, 0.125 and 0.25 mm size fractions), then these fractions should be considered wash loads. A detailed comparison of the sub-surface bed material composition, suspended load size distribution and bed load size distribution should be made to characterize what is wash load and what constitutes bed material load. This comparison is missing from the analysis.

The ISR indicates annual sediment loads will be estimated over a 61-year period from the available simplified sediment rating curves (developed from regression fits to plots of sediment load and discharge). To be meaningful, the reliability of the annual loads needs to be assessed and confidence limits need to be specified on the range of these estimates (Modification 2-1).

Section 7.2.1.3 of the final ISR indicates a "turn-over" analysis will be carried out as part of the study but does not describe what this will entail and what will be produced. In some rivers, a channel-zone sediment budget approach can be used to estimate volumes and fluxes of sediment transferred along the river. This involves relating quantities of erosion and accretion to flux by assigning sediment step lengths. One of the first efforts to estimate sediment loads on gravel-bed rivers using this morphologic approach was carried out in Alaska by Neill (1987). This approach has since been successfully applied to other gravel-bed rivers (Martin and Church, 1995; McLean and Church, 1999). The feasibility of using this approach to estimate gravel and sand bed material load along the Middle and Lower Reaches should be assessed. The method proposed by Neill requires only historic air photos and periodic channel cross sections to estimate sediment volumes and fluxes, both of which are readily available. This approach integrates sediment loads over relatively long time scales (years or decades), which is in many ways more appropriate than intermittent short-term bed load measurements.

Section 7.2.1.3 also stated that AEA will use estimates of tributary sediment loads produced from the Fluvial Geomorphology Modeling Below Watana Dam Study (ISR 6.6 Section 4.1.2.6) to refine the sediment balance in the Geomorphology Study. In order to use model results in place of measurements and direct observations requires a high degree of confidence in the model predictions and sufficient validation/calibration on tributaries to demonstrate the reliability of the predictions. It is unlikely that this can be demonstrated.

The information gained from the single point in time, P61 sampler method, would have more reliability if it was checked against a morphological approach to estimate long-term bed load transport rates.

License participants have no way of knowing whether the study was conducted under anomalous sediment supply and transport conditions or not. By supplementing the existing data with recommended morphological approach the FERC criteria of anomalous conditions would be settled.

Modification 3-3: NMFS recommends using the information in the 7.7 Glacier and Runoff Changes study to help predict changes in sediment supply. NMFS has requested substantial modifications to study 7.7 which are included in a separate enclosure.

Glaciers do not provide an equal quantity or size distribution of sediment to rivers over time. This is especially true of large glaciers that are receding or surging. The Susitna headwaters, the McClaren River, the Chulitna and any other tributary with significant (> 1 square mile) land area covered in ice needs to be evaluated to predict how sediment supply will change.

The potential effects of climate change on sediment supply or geomorphology have also been the subject of various studies (e.g. Walling and Webb, 1996; Moore et al, 2009; Schiefer et al 2010; Knight and Harrison 2009). Not surprisingly, these studies show a complex and variable response in different environments. In many valleys, glacier retreat has produced geomorphic hazards, including mass failures from over steepened valley walls and debris flows generated on moraines. Evidence is presented that glacier retreat will result in possibly transient increases in suspended sediment loads (Moore et al, 2009). These studies also highlight that extrapolation from even decade long sediment monitoring programs may lead to biased projections of long-term sediment yield if variations in sediment supply and catchment response to hydroclimatic and geomorphic controls are not considered (Schiefer et al, 2010).

The sediment balance assessment, which is important for assessing the overall stability of the river, is based on an inter-station comparison of annual sediment loads determined from rating curves generated from a limited number of measurements, which display a wide range of scatter. The accuracy of the estimates is unknown. Other traditional geomorphic methods should be used for assessing long-term channel trends and aggradation/degradation patterns such as (1) sediment budget methods based on comparison of historic cross sections (Martin and Church, 1995), (2) estimates from planform changes (Neill, 1987), and (3) specific gage plots at hydrometric stations (comparison of trends in stage-discharge rating curves over time).

Climate change and variability is likely to result in an increase in the frequency of extreme climate events. Extreme events often lead to immediate erosion events as in the case of abnormally intense rain, or delayed erosion events as in the case of droughts which often portend extreme fire.

To date the applicant has acknowledged that discharges may change in the next 100 years. This 5.5 Geomorphology Study does not discuss the direction or magnitude of change in sediment supply due to either changes in glacier cover or more frequent extreme climate events.

The study was not conducted as provided for in the approved study plan because a potentially major sources of changes to sediment supply (glaciers receding) was ignored.

Objective 4: *Assess geomorphic stability and change in the Middle River and Lower River segments by comparing existing geomorphic mapping with geomorphic feature data from historical aerial photography.*

NMFS appreciates AEA's efforts to find the 1949 aerial photos and incorporate them into the analysis. While NMFS does not agree with all the characterizations of channel forms, we acknowledge it is a somewhat subjective task and the study plan did not lay out a mechanism for different parties to come to agreement.

Objective 5: *Characterize surface area versus flow relationships for riverine macrohabitat types over a range of flows in the Middle River segment from the three rivers confluence area upstream to the dam site using information mapped and digitized from aerial photography.*

The Study Plan (RSP Section 6.5.4.5.2.1) proposed to obtain three sets of aerial photography in 2012 at discharges of 23,000, 12,500, and 5,100 cfs. Subsequently, AEA decided to acquire aerials at a single target flow of approximately 12,500 cfs. AEA concluded that the combination of 2-D hydraulic modeling, bathymetry, and topography collected in the Focus Areas could be used to determine the area of the various macrohabitat types over the range of flows of interest

(ISR 6.5 Section 4.5.3). This is still to be demonstrated. The aerial photography taken at 12,500 cfs should be compared to predictions from the 2-D model to assess the accuracy of these estimates.

Modification 5-1: NMFS recommends taking aerial photos of the Middle River to document the rivers lateral extent at the range of flows that AEA intends to discharge from the dam.

Fish live in the lateral margin of the Susitna River and it is important to know how much lateral habitat will be available at post project anticipated flow in the Middle River. While HEC-RAS (Hydrologic Engineering Center's River Analysis System) model can make predictions, the model will be much more accurate if it can be calibrated with actual photos from some lower flows. Over time the channel will change and the photos of inundation extent will not account for that change, but it is best to start with as accurate a HEC-RAS model as possible.

Currently only a single set of photos exists for 12,500 cfs at the Gold Creek Gage. Without a means to calibrate the model at other flows, one would assume the model would become less precise as you move away from that middle value. At the lower end of the proposed releases (4,000 cfs), it will likely do a poor job of representing lateral inundation.

The study was not conducted as provided for in the approved study plan because you cannot characterize the surface area of a river versus discharge using aerial photos taken at a single discharge.

Objective 6: *Conduct a reconnaissance-level geomorphic assessment of potential project effects on the Lower River segment and Middle River segment, considering stream flow, sediment supply and transport, and conceptual frameworks for geomorphic reach response (Grant et al., 2003; Germanoski, 1989).*

Modification 6-1: NMFS recommends conducting the literature review in the manner of Kellerhals and Gill (1973) to provide case histories and experience related to downstream effects of dams in northern climates. This information should assist in defining potential effects on the Susitna River.

Justification and reasoning for modifications 6-1 and 6-2 will be combined below.

Modification 6-2: NMFS recommends the use of a range of methods including case histories from past projects and site specific analysis to provide a reconnaissance level assessment of project impacts.

The ISR indicated the review of case histories will be completed and it was briefly discussed during the March 2016 ISR meeting. The conclusion is that each river has an individual response to dam structures.

The literature review normally would be conducted near the start of the study, particularly to develop case histories and relevant experience from similar types of projects in similar environments. This experience is useful for guiding the design of the studies and for estimating the direction and magnitude of channel effects. The value of using long-term monitoring and case history experience to assess channel response to flow regulation is illustrated in Kellerhals and Gill (1973) and Church (1995).

The ISR used the conceptual framework developed by Grant et al (2003) for assessing the project effects. The idea of incorporating geological influences in a preliminary assessment of potential downstream effects seems reasonable. The main point of Grant et al, that the broader geological context of any dam should be taken into account, is common sense. The first question that comes to mind is: Why is a general model needed rather than project-specific studies? In applying their "geological framework" it seems difficult to avoid coming up with rather vague predictions that could probably have been developed without benefit of the relations and diagrams. The Grant et al framework was subsequently abandoned and replaced with a “Hierarchy of physical and biological impacts” which is even more generalized than Grant et al. It does not allow predictions to be made of the effects.

A more site-specific approach utilizing experience from past projects is likely to provide more useful information. There are many examples of this approach (Kellerhals and Gill, 1973; Kellerhals et al, 1979; Church, 1995). For example, Church monitored the long-term response of the Peace River to regulation and found that the reduced flows caused gravel to accumulate at major tributary junctions. As a result, rather than experiencing degradation, the river has developed an overall “stepped profile.” The growth of the tributary fans into the river will affect habitat and sedimentation patterns along the tributary channels. Predicting aggradation at the tributary junctions requires understanding of the sediment supply characteristics (total load and size distribution of the load) of each tributary. It is not clear whether these inputs could be defined along the Susitna River at this time.

The study was not conducted as provided for in the approved study plan because the reconnaissance level assessment relied on generalized river concepts rather than focusing on specific knowledge gained from case histories of the effects of dams on rivers similar to the Susitna.

Objective 7: *Characterize surface area versus flow relationships for riverine macrohabitat types in the Lower River segment between the Yentna River confluence (PRM 28.5) and Talkeetna (PRM 98.5); the task includes conducting analyses contingent on a determination that (1) a comparison of riverine habitat in the Lower River segment under pre- and post-project flows is warranted for additional flow conditions and (2) aquatic resource studies need to be continued downstream in the Lower River segment.*

Modification 7-1: NMFS recommends taking aerial photos from the Talkeetna to the Yentna confluence to document the rivers lateral extent at the range of flows that are likely post project.

Fish live in the lateral margin of the Susitna River and it is important to know how much lateral habitat will be available at post project anticipated flows in the Lower River. While HEC-RAS can make predictions the model will be much more accurate if it can be calibrated with actual photos from some lower flows.

Currently only a single set of photos exists for 12,500 cfs at the Gold Creek Gage. Without a means to calibrate the model at other flows, one would assume the model would become less precise as you move away from that middle discharge value. Combining the reservoir operations scenarios with probable contributions from the Chulitna and Talkeetna could suggest one or two other discharges that would be checks on how well the model predicts lateral inundation.

The study was not conducted as provided for in the approved study plan because you cannot characterize the surface area of a river versus discharge using aerial photos taken at a single discharge.

Objective 8: *Characterize geomorphology within the proposed reservoir area and assess reservoir trap efficiency, sediment accumulation rates, delta formation, and erosion and mass wasting potential within the reservoir fluctuation zone and shoreline up to 100 vertical feet above the proposed full-pool elevation.*

To NMFS's knowledge the work on sediment accumulation, delta formation or mass wasting has not been completed.

No modifications are recommended for Objective 8 at this time.

Objective 9: *Assess large woody debris transport, recruitment, and influence on geomorphic forms in the Susitna River between the mouth and the Maclaren River using recent and historic aerial photography and field studies.*

This objective appears to have been completed.

No modifications are recommended for Objective 9 at this time.

Objective 10: *Characterize geomorphic conditions (i.e., channel morphology and sediment dynamics, channel migration zone, large woody debris transport, and erosion and sediment delivery) at stream crossings along access roads and transmission line alignments using data obtained from existing sources and field assessment.*

Fieldwork addressing this objective has not commenced. Nevertheless, no modifications are recommended for Objective 10.

Objective 11: *Integration of Fluvial Geomorphology Modeling below Watana Dam Study with the Geomorphology Study.*

Modification 11-1: NMFS recommends utilizing information from Study 6.5 to test and validate the accuracy of long-term (decadal) predictions from the numerical models. NMFS also recommends utilizing geomorphic methods to make predictions of channel response to changes in sediment supply and discharge so as to provide independent checks on the fluvial model predictions.

The ISR states that the results from Study 6.5 have been used to establish input data and reach boundaries for the 1-D and 2-D bed evolution models. It further states "additional study products in Section 4.11.3 will be used to ensure that the models are developed in an appropriate manner to address the key issues and to provide a reality check on the model results."

Due to the numerous well-documented limitations of morphodynamic models (Cunge, 2008), we believe it is important to fully integrate the fluvial geomorphology modeling (Study 6.6) with the geomorphic studies (6.5). The ISR does not provide a very detailed description of what integration entails or how the geomorphic modeling will make use of the information contained in 6.5. The geomorphic studies (6.5) can be used to strengthen the modeling in several ways:

- To define the most important processes that need to be represented in the models. If understanding whether the system is currently in a state of "dynamic equilibrium" is a truly important consideration, then there needs to be a good understanding of how the river is controlled by its geologic setting, its evolution over Holocene time and its response to changes in climate, vegetation, water and sediment supply over recent times (last few hundred years).
- To provide independent predictions of Project effects as a cross-check to more elaborate modeling predictions (Kellerhals et al, 1976).
- To assist in testing and validating the model predictions and helping to develop realistic assessments of the uncertainty of the predicted responses.

Study 6.5 and 6.6 at times lead NMFS to different conclusions about geomorphic effects of the project on the Susitna River. Until these two approaches suggest the same results it is safe to say one study or the other was conducted under anomalous conditions or the environmental conditions are changing in a material way.

Modification 11-2: NMFS recommends AEA provide details about how the lateral channel changes along the Middle River will be predicted if the effective discharge calculation is abandoned. Since Study 6.5 involves qualitative predictions based on past observations, this is not a request for modeling.

The effective discharge is a geomorphic concept representing that flow, or range of flows, that transport the most sediment over the long term. For the Susitna River at Gold Creek, it would most likely be defined as a range of flows between 20,000 and 35,000 cfs. In the load following scenario these discharges will no longer occur. Presumably some lower discharges would inundate and shape the lateral margins. What flow is AEA suggesting as the new "effective discharge" for the Middle River and will it actually continually change the currently lateral margins or just leave them intact as is, but dry almost all the time?

In the fast, cold middle reach of the Susitna, neither spawning adults nor juveniles spend much of their lives in the center of the main channel. What is happening on the lateral margin of the river and whether slower, shallower habitat is being created or destroyed is most important. Islands and point bars also create additional slower edge habitat.

The subroutine to HEC-RAS 5.0 model which AEA proposes to use is focused on main channel aggradation and incision. While these are the building blocks for predicting other geomorphological changes, it is not really important to salmon if the center of the main channel, which might currently be 9' deep in August, aggrades or incises by two feet. AEA is focusing on questions the 1-D BED models have been designed to answer (main channel aggradation and incision). These may not be the most important questions to be asking.

The approved studies, whether or not they were conducted as provided for in the approved study plan, fail to focus on the geomorphic changes where the fish spend the majority of their time.

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6.6 Fluvial Geomorphology

ISR Review and Study Modifications

For purposes of these comments and proposed modifications, the National Marine Fisheries Service (NMFS) reviewed the body of comments, meeting summaries, and meeting comments related to fluvial geomorphology. These documents included (partial list):

- Initial Study Report (ISR), June 2014;
- ISR, Part D, October 2015, Supplemental Information to June 2014 ISR;
- Updated Fluvial Geomorphology Modeling Approach Technical Memorandum, May 2014;
- Winter Sampling of Main Channel Bed Technical Memorandum, September 2014;
- Decision Point on Fluvial Modeling Technical Memorandum, September 2014;
- Study Implementation Report 2014–2015 (SIR) November 2015, including:
    - Fluvial Geomorphology Modeling Development Technical Memorandum 2014 and
    - Appendix A: 1-D Bed Evolution Model of the Middle and Lower Susitna River.

The services acknowledge receipt of Appendix B: Focus Area-128 2-Dimensional (2-D) Bed Evolution Model but there was not sufficient time to run and review the 2-dimensional model.

NMFS was pleased that Alaska Energy Authority (AEA) presented models and results at the March 2016 ISR meeting. This review focuses on the 1-D Bed Evolution Model (BEM) for the Middle River and Lower River under the existing and max load following OS-1B operation scenarios. NMFS consultants download the models from:
http://gis.suhydro.org/suwareports/SIR/06-Geomorphology/6.6-Fluvial_Geomorphology_Modeling/Initial%201-D%20BEM

The results files were not at this site, so the NMFS's consultant ran the model from the proposed Susitna-Watana hydropower project site (Project) and much of the following discussion comes from his results.

Study Objectives

The following objectives were stated in the Revised Study Plan (RSP) and then agreed to in FERC's Study Plan Determination (4/1/2013):

1. Develop calibrated models to predict the magnitude and trend of geomorphic response to the Project.
2. Apply the developed models to estimate the potential for channel change for with Project operations compared to existing conditions.
3. Coordinate with the Geomorphology Study to integrate model results with the understanding of geomorphic processes and controls to identify potential Project effects that require interpretation of model results.

4. Support the evaluation of Project effects by other studies in their resource areas providing channel output data and assessment of potential changes in the geomorphic features that help comprise the aquatic and riparian habitats of the Susitna River.

The Fluvial Geomorphology Modeling below Watana Dam study is divided into three study components:

- Component 1: Bed Evolution Model Development, Coordination, and Calibration
- Component 2: Model Existing and with Project Conditions
- Component 3: Coordination on Model Output

These three study components are in agreement with the four specific objectives of the RSP.

NMFS Study Modifications

In order to meet the overall Fluvial Geomorphology Study objectives, NMFS recommends the following modifications. Details and justification for each NMFS requested study modifications are included in the pages that follow. (Example: Modification 2-1 indicates it is the first Modification associated with Objective 2.)

1-1 Compare the results of the 1-D and 2-D models across common cross sections and for various identical pre- and post-Project flow conditions.

1-2 Provide detailed information on the fluvial morphology modeling capabilities of HEC-RAS (Hydrologic Engineering Center's River Analysis System) 5.0.0 (1-D model) and SRH-2D 3.0 (Sedimentation and River Hydraulics 2-D model) to demonstrate the real capabilities of both models.

1-3 Limit the use of pass-through nodes to only Devils Canyon within the final version of the 1-D BEM.

1-4 Improve the modeling approach to include a short reach of each tributary as a lateral branch in the 1-D model, such that tributary sediment loads are dynamically computed by the model taking into account the post-Project changes in both water levels and bed levels.

1-5 Describe tributary modeling in the Susitna Middle Reach that will incorporate dynamic feedback effects between the tributaries and the main stem.

2-1 At each Focus Area, present 1-D model results of predicted bed levels for each year over the 50-year simulation period. This data should be presented in terms of location specific curves showing time on the x axis and bed elevation on the y-axis

2-2 Replace or overhaul the Sediment Delivery Index (SDI) approach by using a more physically-based approach in order to develop a more robust assessment of pre- and post-Project accretion rates.

2-3 Account for and explain why sediment gradation along the deep portion of the channel is courser than that on the shallow bar heads, as reported in the WTSM.

2-4 Extend some type of fluvial geomorphologic modeling from mile 29.9 to the Cook Inlet. NMFS agrees that the HEC-RAS based model may be an inappropriate tool for this extremely braided lowest reach which transitions into an estuary.

2-5 Assess the sedimentation and development of deltas at the mouth of the mainstem (e.g., head of the reservoir) and reservoir tributaries.

2-6 Re-evaluate how throughput load and bed load interact to move sand and gravel between Talkeetna and Mile 40.

3-1 Include the effects of climate-change induced alterations to sediment load within geomorphic and geomorphology modeling studies (similar to Modification 3-3 in Study 6.5).

3-2 Demonstrate how the outputs from the fluvial geomorphology models will be used in all other models. Every study from 7.5 Groundwater to 9.12 Fish Barriers is dependent on how the channel changes.

G-1(Global) Select a range of operational scenarios with the intent of bracketing the possible range of future geomorphic change with Project impacts to fish habitat downstream of the Susitna-Watana Dam, which should include, but not be limited to: channel narrowing, bed degradation, coarsening of substrate leading to bed armoring, and decrease in fine sediment.

Summary Comments

Below is the summary of ISR Study 6.6 concerns:

- Only preliminary model results have been presented. Hopefully AEA was already planning to make some of the above modifications.
- 1-D models underestimate sediment transport in gravel-bed rivers (Ferguson 2003), which could lead to underestimation of the effects of the proposed Watana Dam.
- The 1-D bed evolution model (HEC-RAS 5.0 Beta) has been “calibrated” by comparing USGS measurements of transport rates with values computed by the 1-D model. However, this does not guarantee the 1-D model can provide reliable results of bed degradation, especially considering the excessive use of pass-through (‘fixed-bed’) nodes in the model.
- The 1-D (HEC-RAS 5.0 Beta) and 2-D (SRH-2D 3.0 Beta) modeling software used for the bed evolution models in the November 2015 ISR Part D report, were Beta versions not widely used, tested or documented. There is no guarantee that the results presented in the ISR using these Beta versions can be replicated later using the final public release of the software. (HEC-RAS 5.0 was released in February 2016.)

- Preliminary 1-D geomorphology modeling results of the effects of the Watana Dam in the Middle River have been presented using HEC-RAS 5.0 Beta June 2014. Because of stability problems with the software, the model uses pass-through nodes on every island in the model including the Focus Areas, which is not acceptable.
- The 1-D modeling results in the Lower Susitna River show the largest dam impacts (bed changes) farther downstream in the river, which does not seem physically realistic.
- The delay in Study 6.6 negatively affects the progress of other studies that will use the results of geomorphic modeling such as 6.5 (Geomorphology), 8.5 (Fish and Aquatics Instream Flow Study) and 8.6 (Riparian Instream Flow Study).

<u>AEA's Proposed Study Modifications</u>

NMFS does not object to the following study modifications proposed by AEA:

- Use of Ackers and White sediment transport equation instead of Wilcock and Crowe equation as originally planned.
- Include groundwater sources in Focus Areas 2-D hydraulic models.
- Extend Focus Area bed evolution modeling time period when additional information is needed to evaluate tributary fan development.
- Exclude dimensionless critical shear as a parameter for the sensitivity analysis as originally indicated in the RSP (based on use of Ackers White sediment transport equation).
- Do not consider Pacific Decadal Oscillation (PDO) for selection of hydrology for representative wet, average and dry years.
- Exclude Bank Energy Index (BEI) analysis for channel bank erosion, though include more detailed evaluation of ice breakup conditions as driver of bank erosion.

Review by Objective

This material within this objectives section is arranged differently than other NMFS study reviews. NMFS will first describe the challenges which led to the need for the study modification and then present the modification.

NMFS acknowledges that modeling channel morphology on a large river is a difficult task and it is easier to critique what was accomplished than to do it right. Since human activity has either extirpated salmon completely, or greatly diminished the number of species and individuals on most rivers that once contained salmon, it is imperative that both AEA and the services work together to make these models as accurate as possible.

Objective 1: *Develop calibrated models to predict the magnitude and trend of geomorphic response to the Project (Modifications 1-1, 1-2, 1-3, 1-4 and 1-5).*

<u>Challenge 1: Selecting 1-D vs 2-D Model</u>

Given that Ferguson (2003) demonstrated that 1-D models tend to severely underestimate bedload transport in gravel-bed rivers, the entire Susitna River study reach from Project River

Mile (PRM) 29.9 to PRM 187.1 should be modeled using a 2-D BEM for the 50 years of FERC licensing period. However, performing 2-D fluvial geomorphology simulations in such a large modeling domain combined with multi-year modeling periods is not practical at the moment due to current limitations in computer power and a lack of sufficiently detailed channel morphology data. Therefore, AEA's proposed use of a 1-D reach-scale (from PRM 29.9 to PRM 187.1) BEM for assessing the long-term and cumulative effects over the 50 years of FERC licensing period combined with the use of a 2-D local-scale BEM for more detail short-term (~6 months) analyses in 10 selected Focus Areas is a non-ideal, but necessary compromise for modeling the geomorphic effects of the Project. The limitations of the 1-D reach-scale and the 2-D local-scale BEM should be clearly identified and stated such that the usefulness of the modeling results is transparent. The selected Focus Areas for the 2-D local-scale BEM are supposed to be representative of each of the geomorphic reaches where they are located. The main issue with 1-D model is that there is a single width-averaged value of a hydraulic parameter (e.g. depth, velocity, shear stress) as representative of the entire cross section, neglecting the variability across the channel width. This is a good approximation only when the channel section is rectangular in shape. Because bedload transport laws are nonlinear, a disproportionate amount of the total bedload in a cross section is transported along the deepest part of the river channel where velocity and shear stress are normally highest. Figure 1 illustrates how bedload transport in a section of the Susitna River varies by orders of magnitude across the channel width.

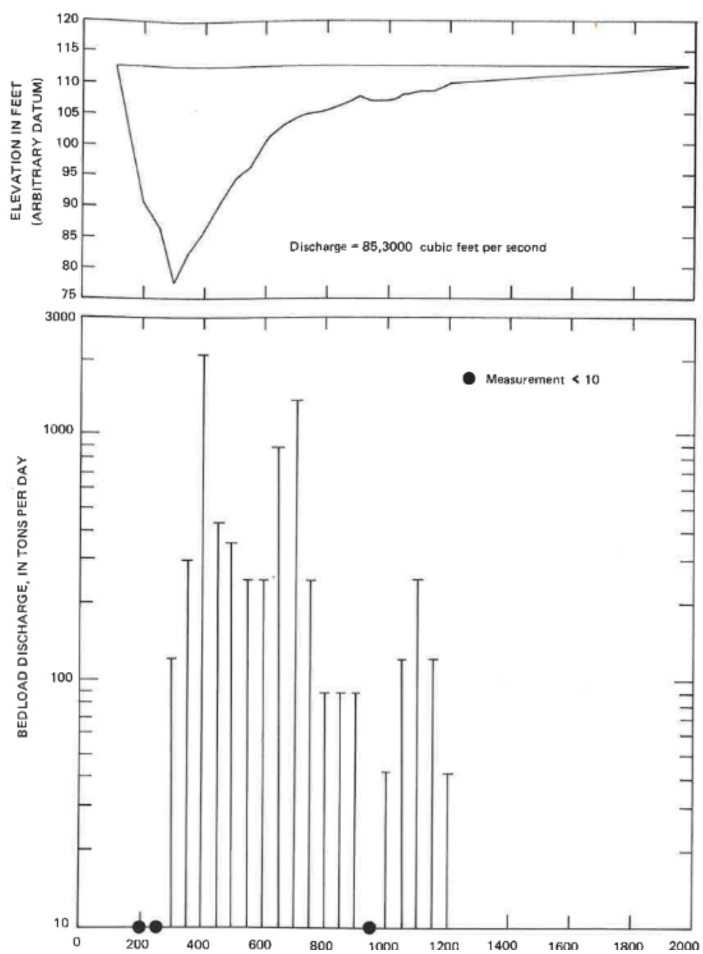

Figure 1. Cross section and distribution of bedload discharge, Susitna River at Susitna Station, August 15, 1984 (Knott et al. 1986).

According to Ferguson (2003) "simple width averaging leads to severe underestimation of bedload transport in most conditions." Ferguson proposes "averaging only in the areas of the channel with above-average depth or shear stress;" but this may be difficult to implement as it will require changing the programming code of the 1-D model. One possibility could be to restrict the 'effective' or 'active' width for sediment transport to only the deepest part of the channel if the 1-D software has that capability; but even in that case the active width will not be constant but vary with discharge. Another suggestion could be to reduce the critical shear stress (or sediment size) to artificially increase bedload transport.

Modification 1-1: NMFS recommends comparing the results of the 1-D and 2-D models across common cross sections and for various identical pre- and post-Project flow conditions during model calibration. The values of shear stress and bedload transport computed by the 1-D model at each section should be compared with the corresponding width-averaged values computed by integrating the results of the 2-D model at the same section. If significant discrepancies are found in width-averaged transport rates between the two models, then different strategies (e.g. active width reduction, decrease in critical shear stress, etc.) should be tested in the 1-D model to try minimizing the discrepancies over the entire flow duration curve, so that the average annual bedload transport computed by both models is similar.

Currently, AEA asks the licensing participants to agree that a large complex river can be represented with a 1-D model that deals with a single channel and a single Mannings N for each cross section. The Susitna is split about ½ the time.

The study was not conducted as provided for in the approved study plan because AEA made large assumptions without any data to back them up.

<u>Challenge 2</u>

AEA's selected models are prototypes.

The following models proposed in the ISR have been selected (TetraTech 2014):

- 1-D Reach Scale Model: HEC-RAS 5.0.0 Beta (U.S. Army Corps of Engineers) and
- 2-D Local Scale Model: SHR-2D 3.0 Beta (U.S. Geological Survey).

Although AEA had access to the Beta versions of these two modeling software packages for some time, they provided no documentation showing the application of these models in similar projects. Therefore, the capabilities of the models remain unproven.

The results of the 1-D BEM model of the Middle Susitna River, developed using the modeling software HEC-RAS 5.0, are quite sensitive to the version of software used, as summarized in the table below.

	Version of HEC-RAS 5.0 modeling software		
	Beta June 2014	**Beta August 2015**	**Official (February 2016)**
Use	Used by AEA (Tetra Tech) in the ISR report	Used by the USFWS in our review	Official version released by US Army Corps to the general public
Quantitative results	1 to 2 ft of degradation	Up to 10 ft of degradation	Unknown - Model did not run due to errors in input data
Qualitative results	Predicted larger degradation with dam in place, which is reasonable	Predicted larger degradation without dam, which is unreasonable	Unknown - Model did not run due to errors in input data

Early additions of complex models not running correctly are a common challenge and NMFS is hopeful that AEA can work through these challenges in the future.

Modification 1-2: NMFS recommends providing detailed information on the fluvial morphology modeling capabilities of HEC-RAS 5.0.0 and SRH-2D 3.0 to demonstrate the real capabilities of both models; including multi-size sediment transport and bed armoring (erosion of surface fines) processes, which are crucial for assessing pre- and post-geomorphic Project effects.

HEC-RAS 5.0 is now officially available (as of 5/26/2016). Especially relevant, are documented applications to similar gravel-bed rivers in glacial systems where the models have been satisfactory validated by reproducing observed bed changes. NMFS recommends that the proposed numerical models be validated by applying them to simulate existing documented case histories of large glacial systems. The 30-year dataset of cross sections from the dams on the Peace River would be a good place to start.

Untested models are being used on the Susitna project. This can be viewed as using cutting edge technology or a recipe for erratic predictions of project effects – or both.

The study is not being conducted as provided for in the study plan because the services understood AEA would use models proven by previous use on other rivers.

Challenge 3

Many nodes (locations where the bed elevation is fixed) were used to make the 1-D model stable and interact with other models (Figure 7).

Modification 1-3: NMFS recommends the final version of the 1-D BEM must limit the use of pass-through nodes to Devils Canyon only.

Nodes are only appropriate when modeling rivers passing through erosive resistant bedrock such as Devil's Canyon.

The models used nodes every time there was channel split or a focus area. This was done because the HEC-RAS 5.0.0 model cannot deal with flow splits and routes the sediment proportional to the distribution water. Also the modelers felt the 2-D needed the 1-D model not to change adjacent to the focus area. The reason to do bed evolution modeling is undermined if you are going to put in nodes every 10 miles.

If any nodes are used outside of Devils Canyon, then the 6.6 study is not conducted as provided for in the approved study plan as the models cease to have any credibility in its ability to model channel incision or aggradation.

Challenge 4

How the 1-D BEM models sediments from tributaries is unclear. This is covered in following in Modifications 1-4 and 1-5.

Modification 1-4: NMFS recommends switching from treating tributaries as static point sources, to a new modeling approach to include a short reach of each tributary as a lateral branch in the 1-D model, such that tributary sediment loads are dynamically computed by the model taking into account the post-Project changes in both water levels and bed levels.

The *Updated Fluvial Geomorphology Modeling Approach Technical Memorandum* seems to suggest that tributaries may indeed be modeled as branches instead of point sources. The ISR indicates that:

> Tasks in this effort [Tributary Delta Modeling] involve creating the sediment inflow rating curves and performing a demonstration of the process to model fan development at a tributary through the 1-D modeling approach (Note: Tributaries within Focus Area will be modeled in 2-D as part of the SRH-2D Focus Area model domain and only require the sediment rating curves from this task). (Section 7.2.1.1.6)

Based on experience from the dam-regulated Peace River in Canada, NMFS mentioned that coarse sediment coming from tributaries downstream from the dam may not be transported by the reduced post-Project river discharges leading to enlargement of alluvial fans/deltas and stepped water surface profile. NMFS requested some clarification on the modeling approach of lateral tributaries, which according to the ISR appear to be modeled as point sources based on sediment rating curves estimated from pre-Project conditions, without accounting for the post-Project reduction in water levels along the Susitna River main stem. Reduced water levels along the main stem will produce a local steeping of the water surface along the tributary mouth and possibly higher flow velocities that could lead to a transient increase in sediment loads due to local erosion. AEA countered that sediment loads from tributaries are very low and they do not expect scour to occur, but sedimentation instead.

However, the intent is not clear, and it is not mentioned when results of this demonstration will be presented. The topic of Tributary Modeling is relevant to pre- and post-Project impacts, and the integration with other studies.

Especially below a dam, tributary contributions of sediment are very important to channel morphology. If tributaries are viewed as static point sources of sediment then the study is not being conduct as provided for in the approved study plan because it fails to incorporate a known crucial element.

Modification 1-5: NMFS recommends clearly describing tributary modeling in the Middle Reach that will incorporate dynamic feedback effects between the tributaries and the main stem, in a way that potential post-Project effects such as upstream progressing degradation along the tributaries (Galay, 1983) or development of stepped profiles along the main stem (Church, 1995) could indeed be reproduced by the 1-D BEM.

One process that tends to reduce the effects of degradation downstream of dams on gravel-bed rivers is the delivery of coarse sediment from tributaries downstream of the dam, as the reduced post-Project discharges become incapable of transporting such sediment, which tend then to form alluvial fans or deltas. For example, Church (1995) monitored the long-term response to regulation on the Peace River in Western Canada and found that the reduced flows caused gravel to accumulate at major tributary mouths. As a result, the Peace River has developed an overall stepped water surface profile.

The ISR describes the proposed Tributary Modeling:

> Numerical modeling of sediment supply will be carried out using software such as HEC-RAS (USACE 2010a), SAMWin (Sediment Aggregation Model) (Ayres Associates 2003), or spreadsheet applications coupling HEC-RAS hydraulic results with an applicable transport function. (Section 4.1.2.6)

In the ISR statement above, it is not clear if the proposed tributary modeling approach will reproduce the effects documented above because it does not demonstrate that there is a dynamic feedback between the main stem and the tributaries. It almost appears as if the tributaries will be modeled simply as point sources of sediment into the main stem, which may not be correct as pre-Project tributary supply and distribution will be different from post-Project supply.

Because post-Project water levels along the main stem of the Susitna River will be typically lower during the summer season when tributary flows are peaking and their sediment supply is highest, the water surface slope along the tributaries discharging into the Susitna Middle Reach will be locally steeper near their mouths, meaning that flow velocity and sediment transport along the tributary near the mouth will locally increase (until a new equilibrium condition is re-established). This potential post-Project increase in sediment loads from Middle Reach tributaries will be neglected if tributary loads are estimated using existing pre-Project conditions and then imposed as static fixed point sources in the 1-D main stem model. Also, if the main stem suffers from bed degradation, the bed level along the tributaries will also degrade following a process of upstream progressing degradation

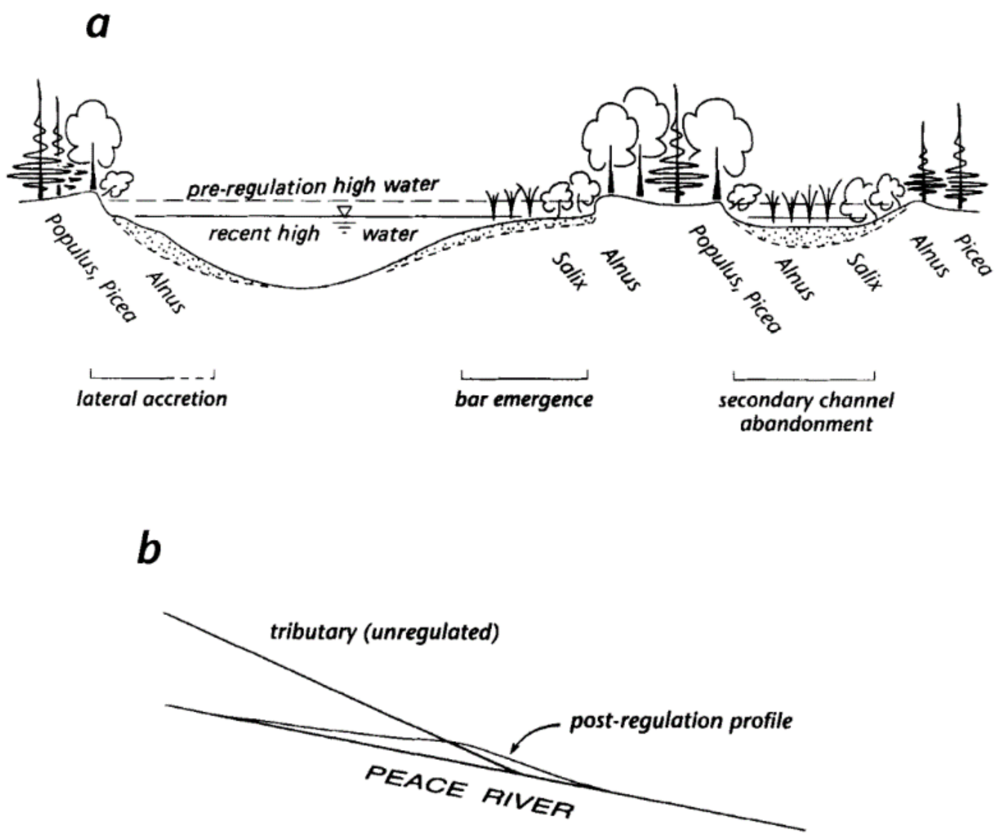

Figure 2. Morphological changes following flow regulation in Peace River: (a) Cross section. (b) Tributary mouth (Church, 1995).

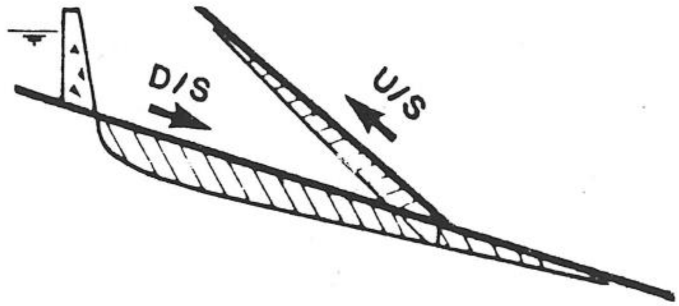

Figure 3. Example of downstream progressing degradation (D/S) caused by a dam, which in turn causes upstream progressing degradation (U/S) along a tributary (Galay, 1983).

Especially below a dam, tributary contributions of sediment are very important to channel morphology. If tributaries are viewed as static point sources of sediment then the study is not being conducted as provided for in the approved study plan because it fails to incorporate a known crucial element.

Objective 2: *Apply the developed models to estimate the potential for channel change for with Project operations compared to existing conditions.*

General Review of Models: Bed Elevation Changes

The Updated Fluvial Geomorphology Model Development Technical Memorandum states that bed elevation changes in the Middle River are small with no degradation downstream of the dam:

> Figure 5.1-9 [Figure 4] shows Middle River bed elevation change at each cross section over the 50-year simulation period with the channel profile for reference... Throughout the Middle River bed elevation changes are predominantly between +/- 1 foot and rarely exceed 2 feet of change in 50 years. (pg. 30).
>
> Although sediment supply of sand and coarser sizes would be eliminated at the dam site, the channel does not appreciably degrade over the 50 year license period. This is due to the very coarse bed acting as a “static” armor. (pg. 42)

Figure 4, below, shows the original Figure 5.1-9 mentioned in the report. The scale on the right vertical axis shows the magnitude of bed elevation change in the range of +4 feet (deposition) to -3 feet (erosion). In agreement with the statements made in the report, largest bed degradation reaches down to -2 feet, but in general it remains small.

Figure 5 shows the bed elevation changes computed by running the HEC-RAS model downloaded from the Susitna-Watana web server (on approximately March 1, 2016), plotted in a similar format as but with the scale of the right vertical axis expanded four times between +16 feet and -12 feet. Notice that degradation is much stronger, reaching values of -10 feet, which is the maximum scour depth allowed in the model (i.e. the model assumes non-erodible bedrock 10 feet below initial bed level).

In order to further verify that the large degradation shown in Figure 5 was not a consequence of erroneous post-processing of the model results on our part, the transverse profiles of the most upstream cross section (PRM 187.2), immediately below the proposed Watana dam site, were extracted as shown in Figure 6. The two cross section plots are direct outputs from HEC-RAS without any post-processing. They show degradation of 10 feet for the Existing condition and 8 feet for the Max LF OS-1b, which is counterintuitive as more degradation will be expected when the dam is included in the model.

These large discrepancies between the reported values (Figure 4) and the values obtained by running the posted 1-D BEM model (Figure 5) should be explained before the 1-D and 2-D BEM results can be considered valid (the 2-D model uses input from the 1-D model).

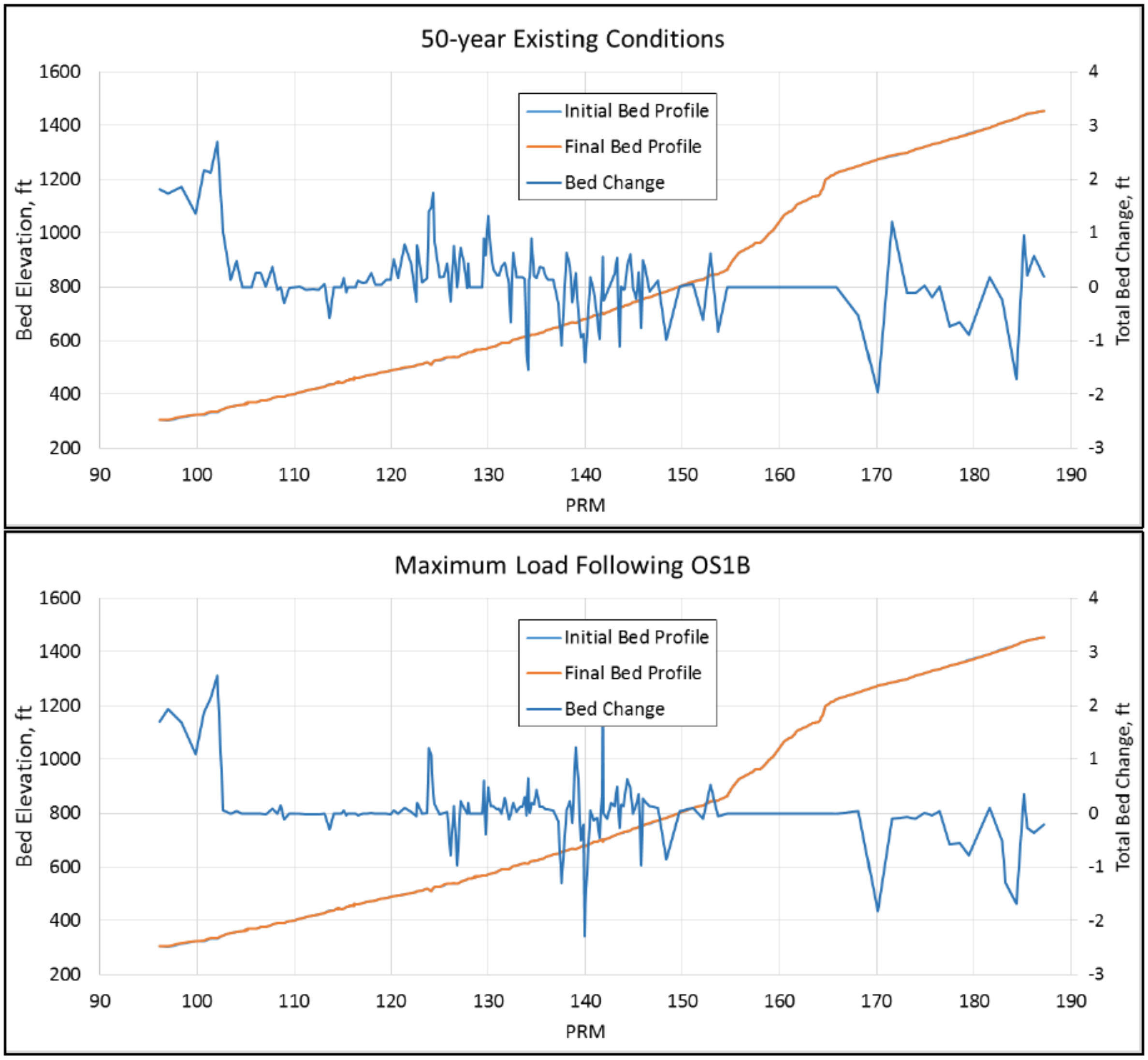

Figure 4. Bed changes along Middle Susitna River over a period of 50 years reported in Figure 5.1-9 of Fluvial Geomorphology Model Development - Technical Memorandum (Nov. 2015).

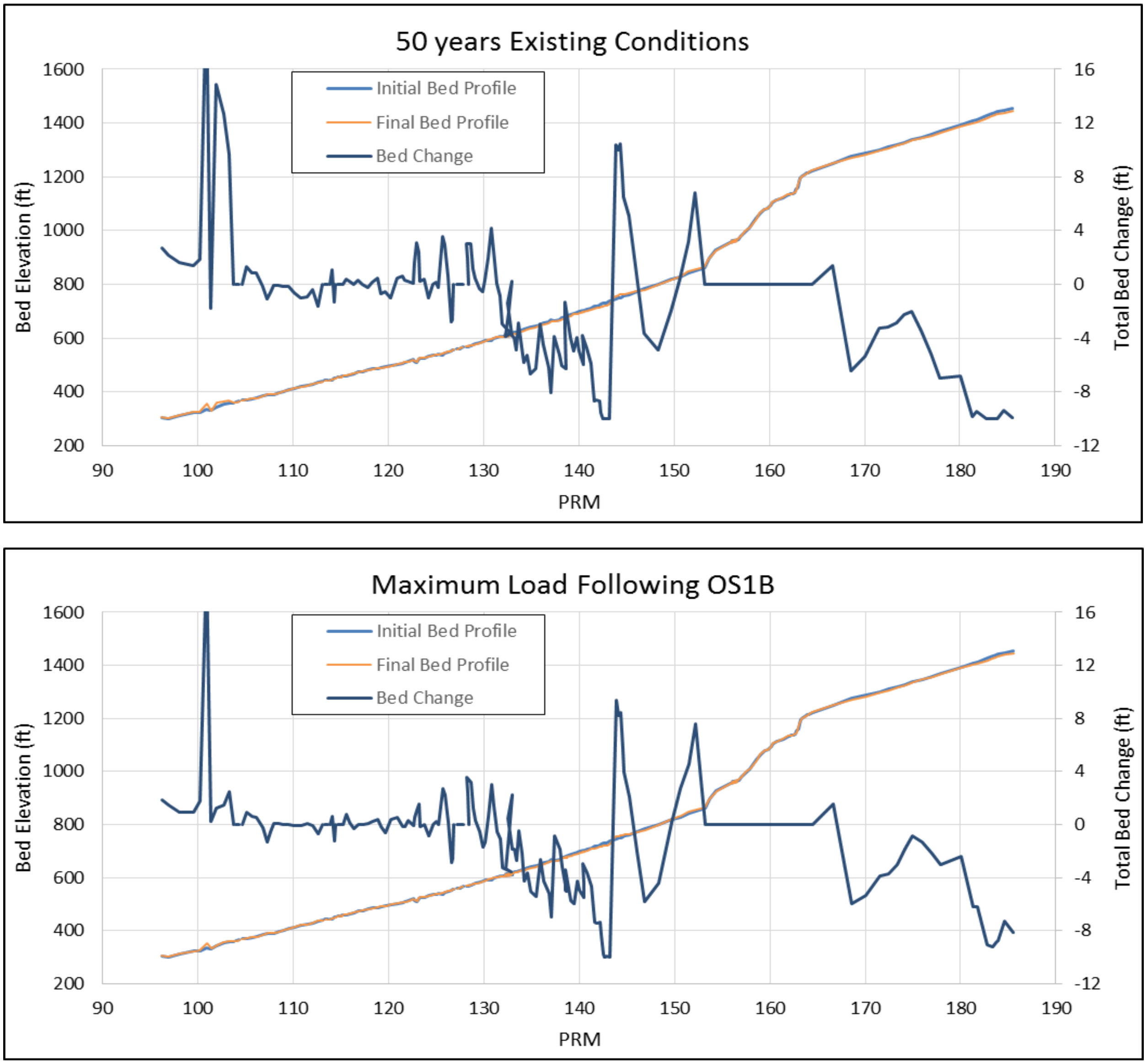

Figure 5. Bed changes along Middle Susitna River computed using 1-D BEM downloaded from Susitna-Watana web server.

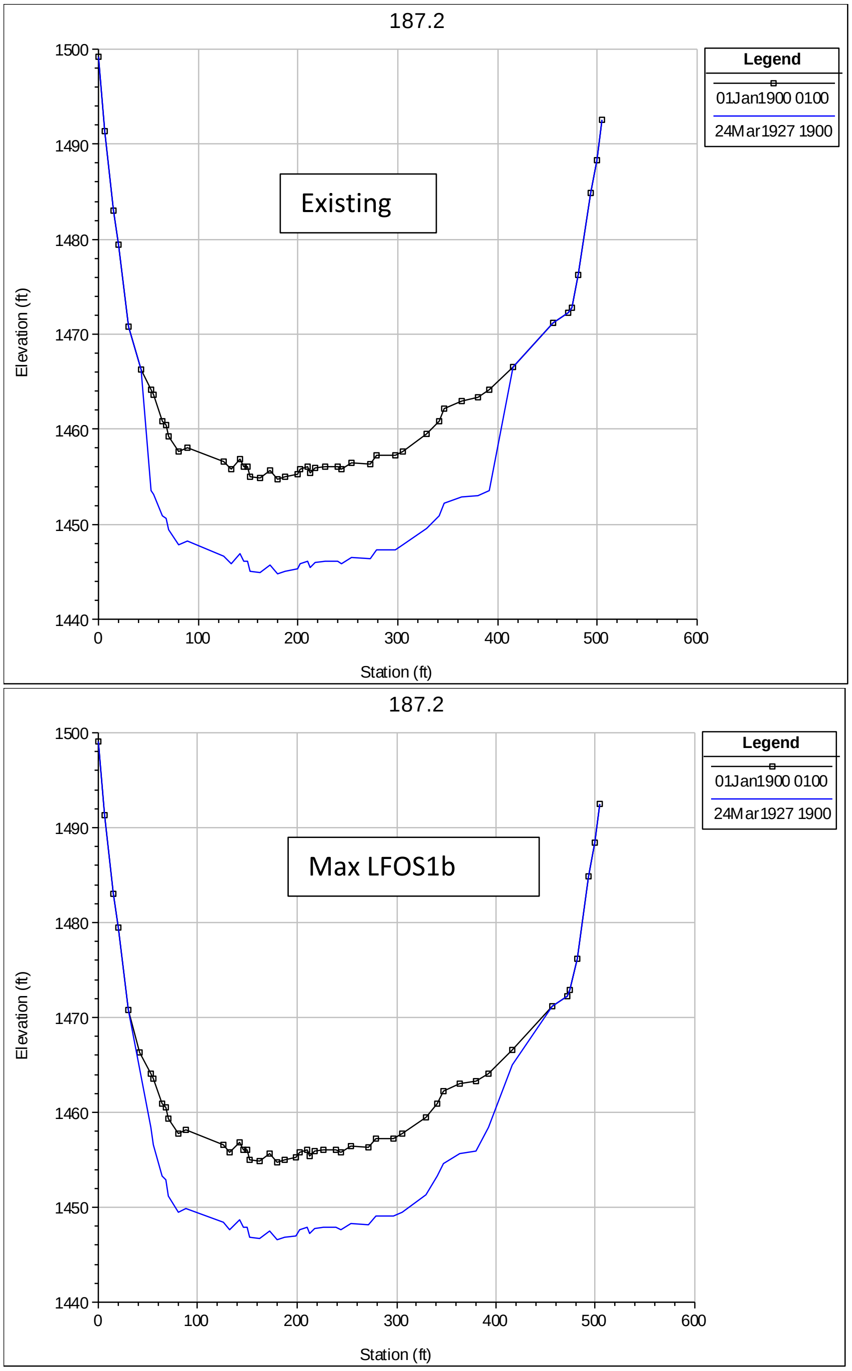

Figure 6. Changes in profile of most upstream Watana cross section (RM 187.2) for the existing conditions (without dam) and Maximum LF-OS1b (with dam) over a period of 50 years.

General Review of Models: Pass-through Nodes

Pass-through nodes are cross sections in the HEC-RAS model where incoming sediment from upstream simply passes through without causing erosion or deposition (i.e. bed change is forced to zero at a pass-through node). The use of pass-through nodes is justified in steep bedrock reaches such as Devils Canyon, but never in alluvial reaches (the Susitna River is an alluvial system) where the bed is free to change due to erosion or deposition. In the HEC-RAS model downloaded, there are 70 pass-through nodes out of 166 cross sections, including Focus Areas FA 104, FA 113, FA 115 and FA 128. The location of pass-through nodes in the Middle River HEC-RAS model is shown in Figure 7, plotted against the bed changes computed for the Existing conditions.

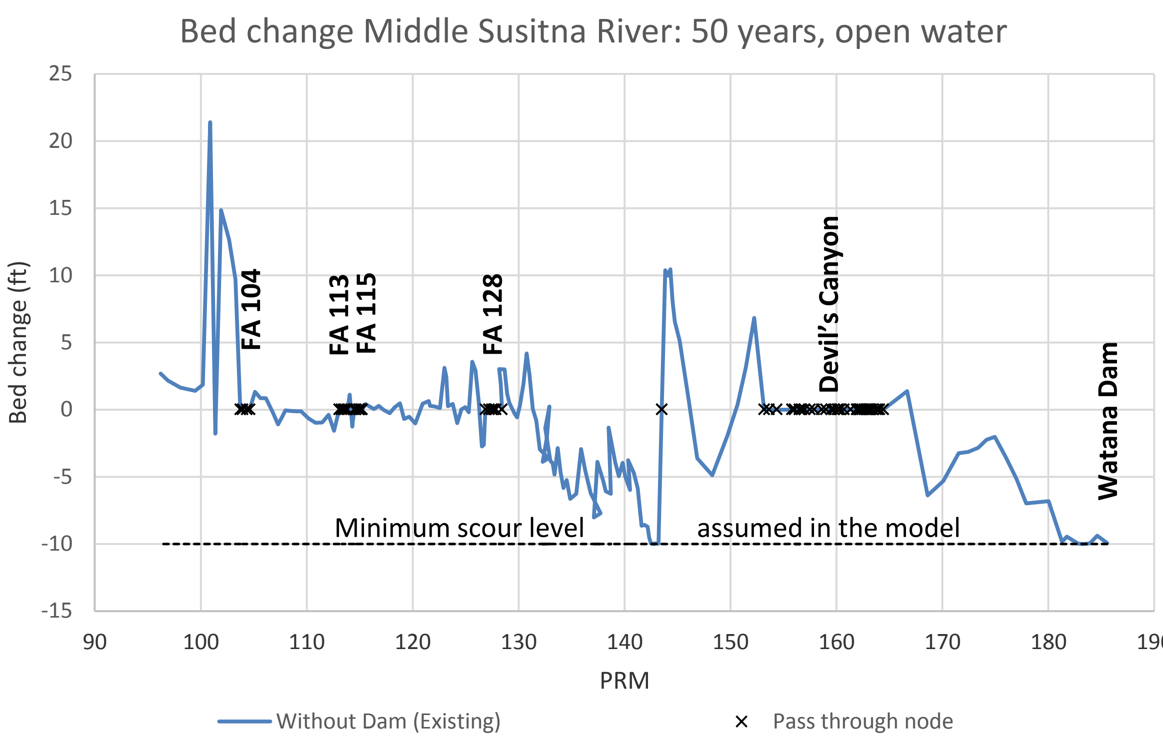

Figure 7. Bed changes in the Middle Susitna River predicted by 1-D open water model for existing conditions (without dam) over a period of 50 years, showing location of pass through nodes.

Figure 7 demonstrates how the presence of pass-through nodes forces bed changes to be zero, which outside Devils Canyon is unwarranted and defeats the main purpose of the 1-D BEM, which is precisely to predict bed changes. The reason for using pass-through nodes in the alluvial flow split areas is due to present limitations in the HEC-RAS 5.0 beta version model, as mentioned in AEA's *Attachment 1: Appendix A. 1-D Bed Evolution Model of the Middle and Lower Susitna River*:

> "…it was decided that the software [HEC-RAS 5.0 beta] is not yet able to reasonably simulate sediment routing through split flows…ultimately leading…to model instability…but for the POC effort, in the Middle River the flow splits, flow junctions, and main channel and side channel cross sections through a split flow reach were set as pass through nodes. (pg. 27)

> A more complete set of [12] split flow reaches will be included in the Middle Susitna River model. (pg. 34)"

AEA's final model is expected to increase the number of flow splits from 4 to 12. Several pass-through nodes (where bed evolution is forced to zero) have been used in the 1-D BEM model due to numerical stability issues with the HEC-RAS Beta 2014 version used by AEA. Pass-through nodes should not be used in the final BEM, except along Devils Canyon. Model stability issues should be addressed to allow for the removal of pass-through nodes.

The excessive use of pass-through nodes also affects the 'calibration' results presented in the report, which consisted of comparing the total load predicted by the model with measurements made near Talkeetna. Since roughly 40% of the cross sections are set as pass-through nodes, the results of the 'calibration' cannot be considered fully valid until the pass-through nodes outside Devils Canyon are removed.

<u>Challenge 5</u>

The downstream geomorphic impacts will usually be most intense near the dam and will progress downstream over time (at a rate that depends on factors such as bedload transport rate, river slope, sediment size, channel width, among others). If the channel immediately below the dam is highly armored, such that the max flow in OS-1b cannot remove the armor, the above statement may not be true. Near the dam, the rate of morphological changes will be fastest immediately after dam construction, but will slowly decrease over time as the river tries to asymptotically approach a new with Project equilibrium state (e.g. the new with Project channel may be deeper, narrower and coarser). Providing 1-D model results at two fixed points in time (year-25 and year-50) may be reasonable for relative comparison between different scenarios; but it will not provide a clear picture of how the river will adjust to the imposed with-Project conditions and their time scales.

Modification 2-1: NMFS recommends presenting 1-D model results of predicted bed elevation for each year over the 50-year simulation period for each Focus Area, especially those closer to the dam. This data should be presented in terms of location specific curves which show time on the x axis and bed elevation on the y-axis. If significant with-Project changes were detected at an earlier point in time (e.g. year 5 or year 10); then this earlier time should be considered for analysis by the 2-D model.

The selection to evaluate mainstem bed incision/aggradation at 25 and 50 years was somewhat arbitrary. It may be appropriate for reaches where the effective discharge will probably be diminished by less than 40% such as below the three rivers confluence. It is not appropriate directly below the dam where annual peak flows are likely to decline by two thirds and sediment supply will be reduced even more.

Currently, adjustment to other models would only be done at 25 and 50 years.

The study is not being conducted as provided for in the approved study plan because there needs to be frequent and timely interchange of data between the 1-D BED model and the other models or it will not be a useful tool.

Challenge 6

When flows in the Susitna River spill over its banks and into vegetated floodplains and side sloughs the additional drag caused by vegetation produces a reduction in over-bank flow velocity and turbulence that induces the deposition of sand transported in suspension, leading to the vertical accretion of floodplains. Since the Watana Dam would trap all incoming sand and silt from upstream, post-Project floodplain vertical accretion downstream from the Dam will be significantly different. The Sediment Delivery Index (SDI) is the current approach proposed to qualitatively assess these changes in accretion rates. But the SDI is rather simplistic, especially considering that better quantitative models already exist (Moody and Troutman, 2000).

Modification 2-2: The SDI approach should be replaced or overhauled using a more physically-based approach in order to develop a more robust assessment of pre- and post-Project accretion rates.

NMFS is concerned that sloughs and smaller side channels which are currently juvenile habitat will over time be dewatered and/or fill in and become lowland vegetation. Whether or not this happens depends on whether water arrives in these side channels and if it is carrying sediment. A physically based approach is likely to give a more accurate deposition prediction.

The SDI was likely derived from data from rivers far removed from the Susitna with fewer ice effects.

The study is not being conducted as provided for in the approved study plan because sediment deposition, an important process to juvenile fish habitat, is being over simplified.

Challenge 7

The sediment size distribution (gradation) of bed material is very important input data for the geomorphic models of Study 6.6. Since bed sediment mobility decreases with sediment size (i.e. large sediment is more stable), the bed sediment size input in the geomorphic models has a strong influence on the predicted bedload sediment transport rate and hence bed changes. Previous sediment size sampling has been based on pebble counts from samples collected on shallow bar heads; but it remained unknown whether those bar head samples were also representative of the deepest portion of the channel.

The new winter sampling was carried out using digital photogrammetry (Winter Sampling Technical Memorandum). On average at each measuring transect, digital photographs of the bed were taken at 12 auger holes drilled through the ice cover. Nine points were selected at each hole to provide around 100 points to develop a pebble count at each transect.

The main conclusion of the winter sampling relevant for Study 6.6 is that "… bar head samples are not representative of the bed material in the deepest portions of the main channel in the Middle River. For the Middle River, the average grain size of the main channel is …larger than for the bar heads, with and average D_{50} of 83.2 mm for the main channel and 59.0 mm for the bar heads."

This means that when these larger grain sizes collected in winter are input into the geomorphic models, they would lead to smaller bed changes compared to those obtained by using the bar head samples data.

Although the Winter Sampling Technical Memorandum provides useful and interesting factual information, it fails to provide an explanation for the reasons why sediment gradation along the deep portion of the channel is coarser than that on shallow bar heads.

Modification 2-3: NMFS recommends explaining why sediment gradation along the deep portion of the channel is courser than that on the shallow bar heads, as reported in the Winter Sampling Technical Memorandum. NMFS further recommends explaining how the 1-D model can be modified to account for the fact that bed roughness changes laterally across the channel.

First, NMFS commends AEA for their excellent effort to measure mainstem pebble counts through the ice; it was a solid idea that was well executed.

Understanding the physical processes and mechanisms responsible for this lateral sorting of bed material sizes across a river cross section is important to guarantee that they are properly accounted for and hence simulated by the geomorphic models. For example, if the lateral sorting is due to lateral changes in the bed shear stress across the channel width (i.e. shear stress higher in deeper portions of the channel), then this process cannot be simulated by the 1-D geomorphic model which assumes constant shear stress across the entire channel width.

The findings of the winter sampling showing variation in bed sediment size between the deep and shallow portions of the channel in the Middle River are quite important and will significantly influence the results of the geomorphic models. Using the coarser deep-channel gradation for the entire cross section would not be acceptable as it will underestimate bed changes and hence the post-Project geomorphic impact of the dam. It should be explained how the models will incorporate this size variability across the channel width; especially for the 1-D model. One possibility to bracket the possible range of changes could be to perform a sensitivity analysis using both the gradations measured in bar heads and deep channel.

To date, main channel roughness was determined by pebble counts on bar heads. It is relatively easy to adapt the model to the larger average pebble size, which determines the bed roughness parameter. The larger challenge is how to deal with clearly variable bed roughness as one moves across the channel.

The study is not being conducted as provided for in the approved study plan because an important model parameter is incorrect and oversimplified.

Challenge 8

1-D BED models results are counterintuitive as effects are most pronounced the farther downstream you are from the dam.

General Review of Models: Decision Point Technical Memorandum

The methodology and decision criteria for extending the model below PRM 29.9 as stated in the Decision Point Technical Memorandum: "If the expected changes due to Project operations are small relative to the range of natural variability the potential impacts are considered minor and extension of the 1-D fluvial geomorphology modeling downstream is not warranted."

In order to represent Project operation, the Decision Point Technical Memorandum uses the Load Following Operational Scenario 1B (OS-1b). For assessing changes due to Project, the following variables were considered in the analysis: channel width; sand and gravel transport mass; bed elevation (channel aggradation or degradation); and flow depth and velocity.

Changes in channel width were estimated based on hydrologic analysis of changes in flow discharges and assuming that the river follows the 'regime' theory. According to regime theory, channel width is proportional to the square root of discharge. Therefore, relative changes in channel width are half the relative changes in flow discharge. Table 5.1-2 of the ISR shows that since the Project will reduce the two-year flood discharge between 4.0% and 15.0%, then channel width would be reduced somewhere between 2.0% and 7.8%. The changes in the other variables were estimated using the 1-D HEC-RAS model version 5.0 beta.

1-D Model Calibration and Validation - Regarding hydraulic calibration and validation, the HEC-RAS model seems to provide reasonable results of discharges and water levels. Therefore, it should provide reasonable estimates of changes in water depth and flow velocity. However, regarding sediment routing calibration, the results of the model do not appear to be reasonable.

The results of sand load transport predicted by the HEC-RAS model in the Lower Susitna River seem to compare well with data from measurements. However, because in the Middle Susitna River sand is transported mainly suspended as washload without interacting with the riverbed, these results do not necessarily demonstrate that the model can predict morphological changes well; as bed changes depend mainly on gravel transport.

Predicted Bed Changes - The results of the 1-D sediment transport model along the Lower Susitna River are shown in Figure 9 (below). Due to its lower slope and proximity to the sea, the river tends to deposit sediment in this reach making it aggradational (i.e. annual bed changes are positive). This figure also shows that the dam operation following LF OS-1b decreases the degree of aggradation in the Lower Susitna River as expected, since sediment trapped from the dam will no longer be delivered to this reach. However, the geomorphic effect of dams on downstream river reaches tends to dissipate away from the dam (i.e., degradation is most intense near the dam and decreases along the river in the downstream direction). Then, AEA's model is rather surprising that the reach LR-1 exhibits much smaller bed change that reaches LR-2 through LR-5, which are located farther downstream.

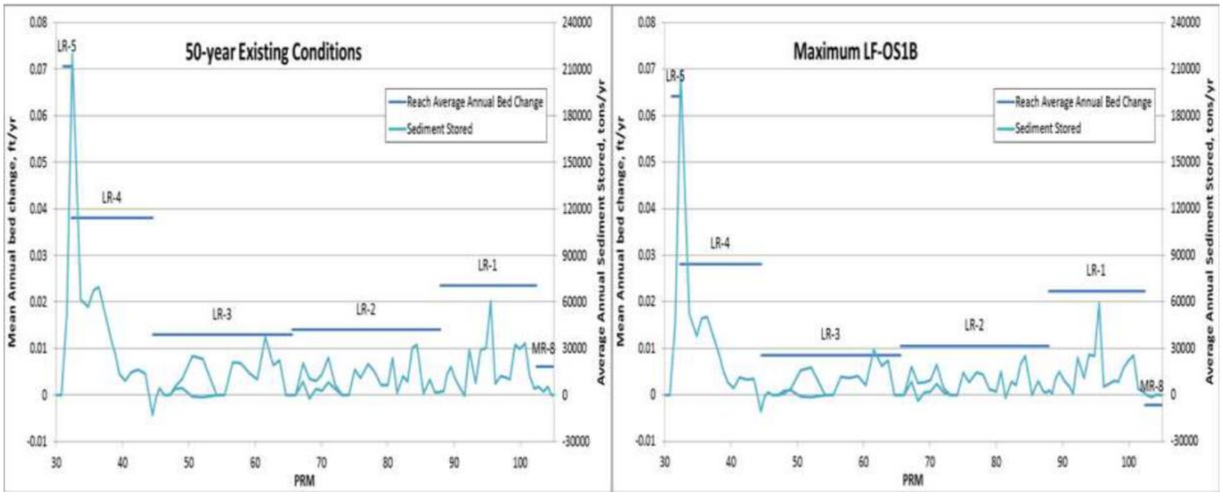

Figure 8. 50 year mean annual bed change predicted by 1-D model for both existing conditions and Maximum LF-OS1b.

Also, Figure 9 shows the difference in bed changes predicted by the 1-D at the end of the 50-year period, computed by subtracting the bed changes with Project (Table 5.3-2) minus the existing conditions (Table 5.3-1). These values represent the net effect of the Project. Again, bed changes increase downstream of LR-1. Surprisingly, the model predicts that Watana Dam will generate larger bed changes in reach LR-4 farther downstream than those in MR-8. These results are counterintuitive, needing clear explanation.

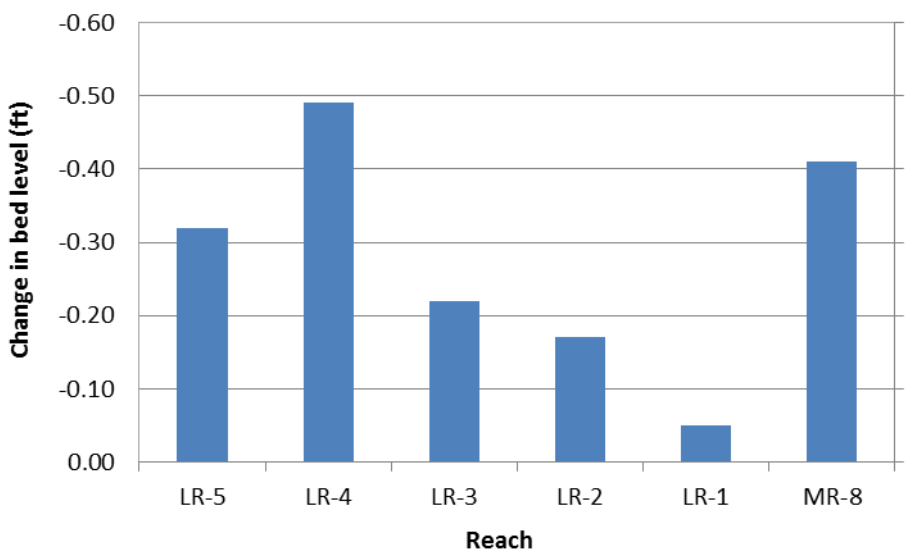

Figure 9. Bed elevation change between existing conditions and LF-OS1b as predicted by 1-D model (i.e. the impact of the Watana Dam on bed levels).

The overall decision of not extending the bed evolution model downstream of PRM 29.9 due to predicted small changes caused by the Project is not currently supported by their modeling. By AEA's own account during the March 2016 ISR meeting, this decision is also not supported by the scientific literature reporting on empirical evidence from other dammed systems. Although

AEA anticipates that the influence of the large tributaries discharging into the Lower Susitna River will dissipate the effects of the dam on hydraulics and sediment transport, the predictions made by the 1-D bed evolution that bed changes increase downstream, or even are larger in reach LR-4 than MR-8, raise some doubts about AEA's 1-D model capabilities.

Modification 2-4: NMFS recommends extending some type of fluvial geomorphologic modeling from mile 29.9 to the Cook Inlet. NMFS agrees that the HEC-RAS based model may be an inappropriate tool for this extremely braided lowest reach which transitions into an estuary.

Based on the modeling results presented above (Figure 8) the channel will aggrade at 9 inches a decade or 4 feet over the first 50-years of the project. 4 feet of bed change in a river that is at least ½ mile wide seems to be outside the range of natural variability. If the model predicts effects that are significant 150 miles below the dam, it is reasonable to expect them to effect the last 30 miles to Cook Inlet also. This rate of aggradation will shorten the length of channel that is intertidal, thereby potentially decreasing eulachon habitat.

AEA is claiming that it is unnecessary to extend any studies below mile 29.9 because there will be not effects this far below the dam. AEA wrote a Decision Point Technical Memorandum saying they would look at available data and make a decision. There is a *non sequitur* here in that the Decision Point Technical Memorandum suggests that the decision will be data based but data from a calibrated model is still not available.

The study is not being conducted as provided for in the approved study plan because decisions about the extent of study effects are coming out before the models that predict those effects are fully functional.

Modification 2-5: NMFS recommends assessing the sedimentation and development of delta growth at the mouth of the mainstem (e.g., head of the reservoir) and reservoir tributaries.

This modeling effort would be best developed in coordination with Objective 8: Reservoir Geomorphology of Study 6.5. To understand if fish will be able to exit the head of the reservoir or enter reservoir tributaries it is important to know how the deltas will form in the varial zone.

NMFS suggests that as deltas grow by deposition of coarse sand, gravel and cobbles, and backwater effects upstream, the footprint of the reservoir will grow. Also, such deltas may affect fish habitat and fish passage. AEA has stated that the 1-D model starts downstream from the dam and that reservoir sedimentation is not part of Study 6.6, but instead it is modeled by the 3D model EFDC as part of the water quality modeling studies. However, it was later stated that it is not planned to use the EFDC model to model coarse sediment or to undertake long-term simulations of reservoir or tributary sedimentation. Also, it is clear that it would be difficult and time consuming to apply this 3D water quality model to answer geomorphic questions associated with long-term deposition in the mainstem and tributaries. Therefore, the modeling of delta growth and gravel deposition in the reservoir seems to have been ignored for the moment. However, modeling of deltas using 1-D and 2-D models has been added to the current modeling plan.

The study is not being conducted as provided for in the approved study plan because changes to the channel above Watana are not being assessed.

Challenge 9

AEA showed results of 'throughput' sand load transport predicted by the HEC-RAS model in the Lower Susitna River, which compared well with data from measurements. These results do not demonstrate that the model can predict morphological changes since more than 90% of the load consisted of sand throughput load, and completely mask the transport and exchange of gravel through the reach. In the Middle Susitna River, sand is transported mainly suspended as washload, without interacting with the riverbed. Morphological changes such as erosion or deposition depend mainly on gravel transport.

Modification 2.6: NMFS recommends re-evaluating how throughput load and bed load interact to move sand and gravel between Talkeetna and Mile 40.

Since the Lower River bed from Talkeetna to about mile 40 is mostly gravel per the Winter Sampling Technical Memorandum the argument that the load is 90% sand as throughput is counterintuitive. At least some sand would settle out and be on the bed.

The study is not being conducted as provided for in the approved study plan because the model is compartmentalizing movement of sand and gravel which is not how the natural system works.

Objective 3: *Coordinate with the Geomorphology Study to integrate model results with the understanding of geomorphic processes and controls to identify potential Project effects that require interpretation of model results.*

Objective 4: *Support the evaluation of Project effects by other studies in their resource areas providing channel output data and assessment of potential changes in the geomorphic features that help comprise the aquatic and riparian habitats of the Susitna River.*

Objective 3 and 4 will be treated as one and modifications apply to both.

Modification 3-1: NMFS recommends that the effects of climate-change induced alterations to sediment load be included in AEA's analyses (Modification 3-3 in Study 6.5 Geomorphology).

NMFS believes that the sediment supply from all tributaries with a significant portion of their land area covered with ice may change over the life of the dam.

AEA stated (ISR, March 2016) that it was not a concern because the material was mainly sand and that the river was already transporting sediment at capacity. Later on, in the discussion AEA stated that much of sand load in the river was transported as "throughput load", which is another way of saying it is wash load (i.e., the fraction of the sediment load that is supply limited). The sediments in glaciated watersheds usually consist of a wide range of material, from fine silt to gravel and boulders. On relatively steep river systems, the finer fractions (sand, silt and clay) will be supply limited, so a change in sediment supply due to glacial and climate-induced changes will result in a change in sediment load. Also, even if a river is transporting at full capacity now, it could transport more sediment if discharges increase in the future. We recommend that results from Study 7.7 be fully incorporated into the geomorphology studies to account for glacial and climate-induced changes.

The study was conducted under environmental conditions that are rapidly changing in a material way as the percentage of ice covering the upper tributaries declines.

Modification 3-2: NMFS recommends demonstrating how the outputs from the fluvial geomorphology models will be used in all other models. Every study from 7.5 Groundwater process to 9.12 Fish Barriers is dependent on how the channel changes once the dam is constructed.

This modification will be best accomplished by a new study for Model Integration. A New Study request for Model Integration is included as an enclosure.

Modification G-1: NMFS recommends AEA select a range of operational scenarios with the intent of bracketing the possible range of future geomorphic change with Project impacts to fish habitat downstream of the Susitna-Watana Dam, which should include, but not be limited to: channel narrowing, bed degradation, coarsening of substrate leading to bed armoring, and decrease in fine sediment.

Stream narrowing due to reductions in peak open water flow discharges and consequent vegetation encroachment, channelization and disconnection from the flood plain could lead to loss of juvenile habitat. Similarly bed degradation (lowering) and associated water level lowering that could lead to partial or total abandonment of side channels or sloughs and lowering of riparian groundwater table both of which may affect juvenile fish habitat. Coarsening of the gravel/cobble substrate due to bed armoring (erosion of smaller gravels) could lead to substrate size that was too large for many salmon to spawn in. The decreased supply of fines could affect the estuary habitat for the fish species that live there which are an important food source for Cook Inlet Beluga Whales.

Currently only one operation scenario has been analyzed, OS-1b.

The study is not being conducted as provided for in the approved study plan because operation scenarios implies multiple scenarios and the studydoes not meet the spirit of our nations environmental laws which ask project proponents to evaluate a range of activities to balance energy development and resource protection.

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7.5 Groundwater Studies

ISR Review and Study Modifications

National Marine Fisheries Service's (NMFS) comprehensive review of the Initial Study Report (ISR) and all preceding groundwater study documents begins with a list of the study Objectives presented in the Federal Energy Regulatory Commission (FERC) Study Plan Determination (4/1/2013) and bullets of the 11 modifications NMFS currently recommends for the Groundwater Study.

The documents reviewed consist of the June 2014 Interim Study Report, the 2014–2015 Study Implementation Report (SIR), material presented at a technical team meeting webinar held on December 5, 2014, the ISR meetings held March 24, 2016 and two technical memoranda:

- Preliminary Groundwater and Surface-Water Relationships on Lateral Aquatic Habitats within Focus Areas FA-128 (Slough 8A) and FA-138 (Gold Creek) in the Middle Susitna River and
- Groundwater and Surface-Water Relationships in Support of Riparian Vegetation Modeling .

NMFS's consultant was also tasked by the Alaska Energy Authority (AEA) with reviewing the Final Study Plan (FSP) (July 2013) which is not a document listed in the Integrated Licensing Process and was not approved by FERC. There are a number of discrepancies in work tasks between this document and the FERC Study Plan Determination which have remained unresolved.

Study Objectives

On May 31, 2012 NMFS requested a groundwater study with eight objectives. During the next five months very similar objectives, but with changing tasks, were included in both the AEA's Study Plan and Revised Study Plan (RSP). NMFS requested changes in groundwater objectives and tasks in our Study Plan Comments (November 14, /2012). FERC's Study Plan Determination (April 1, 2013) lays out the following objectives:

1. Synthesize historical and contemporary groundwater data available for the Susitna River groundwater and groundwater dependent aquatic and floodplain habitat, including data from the 1980s and other studies including reviews of groundwater /surface water interactions in cold regions.
2. Use the available groundwater data to characterize large-scale geohydrologic process-domains/terrain of the Susitna River (e.g. geology, topography, geomorphology, regional aquifers, shallow groundwater aquifers, and groundwater/surface water interactions).
3. Assess the potential effects of Watana Dam/Reservoir on groundwater and groundwater-influenced aquatic habitats in the vicinity of the proposed dam.

4. Work with other resource studies to map groundwater-influenced aquatic and floodplain habitat (e.g. upwelling areas, springs, groundwater-dependent wetlands) within the Middle River Segment of the Susitna River including within selected Focus Areas.
5. Determine the groundwater /surface water relationships of floodplain shallow alluvial aquifers within selected Focus Areas as part of the Riparian Instream Flow Study. (The RSP listed in the FERC determination is more detailed.)
6. Determine groundwater /surface water relationships of upwelling/down welling in relation to spawning, incubation, and rearing habitat (particularly in the winter) within selected Focus Areas as part of the Fish and Aquatics Instream Flow Study. (The RSP listed in the FERC determination is more detailed.)
7. Characterize water quality (e.g. temperature, dissolved oxygen [DO], conductivity) of selected upwelling areas that provide biological cues for fish spawning and juvenile rearing, in Focus Areas as part of the Fish and Aquatics Instream Flow Study. (The RSP listed in the FERC determination is more detailed.)
8. Characterize the winter flow in the Susitna River and how it relates to groundwater /surface water interactions. (The RSP listed in the FERC determination is more detailed.)
9. Characterize the relationship between the Susitna River flow regime and shallow groundwater users (e.g. domestic wells).

FERC Ordered Modifications

Additionally, FERC ordered the following two modifications to the 7.5 Groundwater Study design:

1. FERC ordered that AEA include relevant projects in the literature review.
2. FERC ordered that AEA consult with the Technical Working Group on the construction of the necessary data sets for the MODFLOW RIP-ET package (a new evapotranspiration package the U.S. Geological Survey's groundwater-flow model), and file no later than June 30, 2013, the following:
   - A detailed description of the specific methods to be used to relate the data of Study 11.6 (riparian vegetation) to plant functional groups.
   - A detailed description of the specific methods to be used to relate the rooting depth data from Study 8.6 (riparian instream flow) and the water level data from Study 7.5 (groundwater) to extinction and saturated extinction depths.
   - A detailed description of the specific methods to be used to estimate the shape of the transpiration flux curves.
   - Documentation of consultation with the Technical Working Group, including how its comments were addressed.

NMFS notes that AEA did expand their literature review per #1 above to include relevant projects. At the March 24, 2016 Initial Study Report meeting AEA suggested that groundwater recharge can be simulated using simpler methods than the MODFLOW RIP-ET package. NMFS concurs with AEA's suggestion.

NMFS Study Modifications

NMFS requests the following 11 modifications to study 7.5 which are explained in more detail and justified under the associated, corresponding objective:

1. Include a basin-scale groundwater flow assessment (Objective 2).
2. Insure that groundwater modeling studies are able to simulate short-duration fluctuations (within 30 minutes) in surface water/groundwater levels (Objectives 5 and 6).
3. Base upscaling of the groundwater information on a hybrid upscaling approach (Objective 2).
4. In a single Pilot Scale area, demonstrate that the various models can interact to produce useable data with realistic error bars (Objective 5 and 6). (This request is refined and justified in the Model Integration New Study Request.)
5. Evaluate changes in groundwater temperature and dissolved oxygen from proposed project operations (Objective 5).
6. Assess the current and future flows that will be required to breach the head-of-slough barriers (Objective 6).
7. Collect snow survey data at selected Focus Area so snowmelts contribution to the groundwater can be included (Objectives 5 and 6).
8. Produce maps that show the change in quantity of flood plain macro habitats caused by changing groundwater (Objective 4).
9. Install additional wells in all Focus Areas except FA-128 so that 2-dimensional ground water maps can be completed (Objectives 5 and 6).
10. Assess the effects of main channel aggradation or incision on Focus Area groundwater (Objectives 5 and 6; Model Integration).
11. Measure of vertical groundwater gradients through nested observation well pairs (Objectives 5 and 6).

<u>Review of the ISR</u>

This technical review is organized by study objective. Within the discussion for each objective, subsections are presented providing comments on study methods, study results, and study variances from the FERC-ordered study plan as presented in project documents to date. Finally NMFS recommended study modifications are listed.

The heart of understanding the potential effects of the proposed dam on groundwater/surface water interaction and on aquatic habitat for juvenile salmon are contained in methods section of study Objective 6 (Methods, pg. 13). This section lists nine issues or challenges with the existing groundwater model which AEA needs to address before this model is coupled with other project models.

Objectives 5 and 6 support the Riparian In-Stream Flow and Fish and Aquatics In-Stream Flow studies, respectively. The objectives developed for each of these studies include assessment of potential hydroelectric project effects on aquatic habitat and riparian vegetation. These two objectives are evaluated as one because of the substantial overlap.

Review by Study Objective

Objective 1: *Synthesize available historical and contemporary groundwater data for the Susitna River groundwater and groundwater dependent aquatic and floodplain habitat, including data from the 1980s and other studies including reviews of groundwater /surface water interactions in cold regions.*

<u>Methods</u>

This study element consists of a broad-based literature review and database search within the University of Alaska Fairbanks Library and Alaska Resources Library and Information Services (ARLIS) databases. The latter houses documents from the original 1980s Susitna River study efforts.

<u>Results</u>

Section 5.1 of the Groundwater ISR presents infrared aerial imagery. These data could be potentially useful for investigating changes to the Susitna River during the 1970 – present day period of time. Images from the 1970s for presentation into the record should be annotated more specifically as to date or further explanation of the vague time reference presented.

The principal work of this study element is contained in Appendix C of the November Groundwater SIR report. In general, this review appears to be a thorough and complete compendium of information gleaned from other reports. The current study plan approach is to "expand" or "upscale" the results of groundwater models developed at selected Focus Areas. Prior studies concluded that the groundwater models are not transferable to other sloughs. The dichotomy between these two mutually exclusive methodologies is unaddressed and unreconciled and may be a fundamental factor in the evaluation of work conducted under the FERC-ordered study.

This is finding from the prior studies is highly pertinent to this review. Specifically, the finding states: "This report (R&M and WCC, 1985) concludes that because of the substantial differences among sloughs in the hydraulic and thermal behavior, detailed projections of slough discharge or temperature variations relative to mainstem conditions could only be made if mathematical models are constructed for each individual slough. Additional field investigations would also be necessary to generate input data for the models, and it is expected that different sloughs will have different discharge responses to project conditions."

A similar finding was produced by Harza-Ebasco (1984). The1980s investigators were not hampered by a lack of modern technology to study and understand groundwater flow systems. MODFLOW for example, was first published in 1984 and was a well-established technology at that time. A two dimensional digital groundwater flow model and a temperature transport model were also developed as part of the Susitna River studies during this period. The present study does not incorporate these important 1980s findings about the unique qualities and complexities of each slough. Rather, this study engages in a process of modeling, characterizing, and up-scaling (see subsequent sections of this review) that tracks in a different direction to those previous findings. This is done without adequate justification or demonstration of the viability for this approach and reconciliation with the previous findings.

The current approach relies to a great extent on groundwater modeling efforts and an up-scaling process that is poorly-defined and has not been successfully completed and demonstrated to be viable; even at the best monitored Focus Area.

Variances

This literature review was produced in November of 2015, two years behind schedule. The lack of attention to the 1980's studies may have led to not being able to foresee operational difficulties in the current study plan.

Modifications

No modifications are recommended for Objective 1.

Objective 2: *Use the available groundwater data to characterize large-scale geohydrologic process- domains/terrain of the Susitna River (e.g. geology, topography, geomorphology, regional aquifers, shallow groundwater aquifers, and groundwater /surface water interactions).*

Methods

The methods presented for this study element are not clearly described.. The ISR references several documents produced by the American Society for Testing and Materials (ASTM), but it does not say which part of the document AEA plans to follow.

The ISR text states that after characterizing hydrogeologic units present in the study area, the relationship between regional and local groundwater systems would be defined, according to methods described by Anderson [1970] for the Tanana River basin. This study was primarily a basin-scale assessment of physiography, geology, groundwater availability, surface water availability, and water quality. In other words, the study of Anderson (1970) would be a more appropriate guide toward characterizing the Susitna River basin hydrology, not for linking regional and local groundwater systems.

The first two study elements of the Groundwater Study – (1) Existing Data Synthesis and (2) Geohydrologic Process Domains – require geologic and soils data for the broader study area and critically, along the Middle River. It should also be recognized that one of the work products from the Geomorphology Study has been a surficial geologic map of the entire Middle River [Tetra Tech, 2014]. This data product is available in mapbook form as part of the Geomorphology ISR. This map would provide critical information in completing the first two study elements.

To summarize, the methods presented in this section are not sufficiently detailed to allow for evaluation of whether project objectives will be met.

Results

Findings under this study objective are almost completely unreported. Thus, it is not possible to determine the status of work towards meeting the goals of this objective.

Expanding the results of the Focus Areas (up-scaling) appears to be highly dependent upon mapping efforts under this study element. In light of the 1980s findings about the unique characteristics of sloughs, there is a considerable lack of clarity on how or whether this is going to work, especially at the scale needed for habitat evaluations. A draft or pilot-scale work product is needed to understand this better.

Variances

This study element was originally scheduled for completion in the fourth quarter of 2013, but has not been completed and is a variance. This variance could potentially affect completion of the study objectives. Numerical groundwater development relies on conceptual understandings of the groundwater system. This study element is focused on developing conceptual understanding of the groundwater system, and should be a pre-requisite for development of numerical groundwater flow models. It is important to stress that successful completion of this study element is critical to completion of all other Groundwater Study objectives.

Modification 1: NMFS recommends including a basin-scale groundwater flow assessment as described below.

Basin-scale analyses should include an analysis of the basin water budget and address topics that include recharge rates (and variations due to altitude or other factors throughout the basin); glaciers; permafrost; types, lithology, and transmissivity of aquifers and confining units; expected water table and/or potentiometric surface configurations; and discharge to tributaries. This type of analysis may best be conducted by sub-basin analysis, particularly the sub-basin above the proposed dam and sub-basins below, or sub-basins contributing to the Focus Areas.

Owing to the sparsity of data, part of this description and analysis would be conceptual. General concepts and expected processes and even quantification of flow systems as "best estimates" could be derived from more detailed studies in other relevant or similar areas. Such an analysis would provide useful and important context and explanation for understanding the processes involved in the "Broad-Scale Mapping."

Parts of this assessment appear to be contained in the groundwater study element for geohydrologic process-domains, but it is not clear what the outcome of that study element is going to be since it has not yet been completed. This assessment would also inform the riverine groundwater assessment component "*7.5.4.3. Upwelling / Springs Broad-Scale Mapping*" by assisting the task to "characterize the identified upwelling/spring areas at a reconnaissance level to determine if they are likely to be (1) mainstem flow/stage dependent, (2) regional/upland groundwater dependent, or (3) mixed influence."

One of the main reasons to perform this study is that it is required input to the groundwater model developed at Focus Area FA-128 and the value used for the preliminary modeling effort differs by the regional value determined from the 1980s studies by an order of magnitude. This unexplained deviation indicates that the modeling study was conducted under anomalous environmental conditions or that environmental conditions have changed in a material way. This analysis would put into context the expected quantity of upwelling in the river bottom lands and tributaries. For example, if a groundwater flux density of a certain amount is estimated or measured in a Focus Area, how does this compare to what might be expected from a basin analysis perspective? How important is groundwater to the flow of the river on a season-by-season basis?

It is common in groundwater studies involving large and small basins to include such an analysis. There are many examples of this type of analysis found in reports by the U.S. Geological Survey around the country. There are also good examples in Alaska such as Kikuchi (2013) and Dearborn and Barnwell (1975).

In summary, a large amount of effort is being put into understanding groundwater processes important to the riverine and immediately adjacent environments of the Susitna River bottomlands. A thorough understanding of these processes cannot be obtained without extending the domain, at least on a reconnaissance level, to the limits of the Susitna basin including a more thorough analysis of regional and sub-regional groundwater flow..

Modification 3: NMFS recommends that the up-scaling process used to tie information gained in the Focus Areas to the larger river use the hybrid approach described in Appendix-C, Page 21 of the SIR.

Objective 2 of the RSP contains the core of the groundwater studies' approach to the problem of upscaling - the final step will be identifying the relationship between the process-domain river segments and the planned Focus Areas. This will facilitate the expansion of the analysis of potential Project effects on groundwater /surface water interactions from the Focus Areas individual study areas back to the larger process-domain river segments.

The current study plan approach is to expand or upscale the results of groundwater models developed at selected Focus Areas, yet prior studies (1980s) concluded that the groundwater models are not transferable to other sloughs (R&M and WCC, 1985): "This report concludes that because of the substantial differences among sloughs in the hydraulic and thermal behavior, detailed projections of slough discharge or temperature variations relative to mainstem conditions could only be made if mathematical models are constructed for each individual slough. Additional field investigations would also be necessary to generate input data for the models, and it is expected that different sloughs will have different discharge responses to project conditions."

The mutually-exclusive dichotomy between the current RSP approach and the 1980s conclusions is not addressed orreconciled and creates doubt about the viability of the RSP groundwater study methodology. The feasibility of the current approach relies to a great extent on groundwater modeling efforts that have thus far not been successfully completed and demonstrated to be viable, even at the best monitored Focus Area.

The1980s investigators were not hampered by a lack of modern technology to study and understand groundwater flow systems. MODFLOW for example, was first published in 1984 and was a well-established technology at that time. The present study ignores the findings of the 1980s and is engaged in a process of modeling, characterizing, and up-scaling that tracks in a different direction to those previous findings without adequate justification or demonstration of the viability for their approach and reconciliation with prior conflicting findings.

The finding that all sloughs are unique and complex and would require individual models would result in an onerous and likely unworkable modeling task. Alternatively, abandoning the groundwater modeling in lieu of only qualitative evaluation of habitat impacts would likely result in unnecessarily conservative and insufficiently accurate assessments of project effects. We agree with a hybrid approach, as suggested by the SIR (November, 2015) in its review of prior studies. However, this represents a significant modification of the current study. The hybrid approach is succinctly described in Appendix-C, Page 21of the November 2015 SIR report:

"A hydrid (sic) approach would include reviewing differentiating characteristics of sloughs (such as the presence of tributaries, upland soil/geology type, apparent influence from mainstem flows, influence from overtopped-berm flows, etc.) and their hydrologic responses to see if sloughs with similar characteristics show similar responses. If this is the case, representative sloughs could then be focused on and potentially modeled, with simulated results extrapolated to other sloughs that are expected to have similar responses."

The SIR text also suggests that sufficient data exists to perform this evaluation. However, since substantive data to support this view has not yet been reported and analyzed, we do not concur that this has been demonstrated.

This proposed modification should be adopted for the following reasons. First, the lengthy delay in reviewing prior studies prevented identification of the problem associated with unique and complex sloughs until after modeling studies were well underway. The variance noted in the schedule has been a material reason why mid-course corrections and modifications of the study plan have not been previously identified and implemented.

Also, the modeling does not follow standard groundwater modeling methodologies as described in the references cited in the RSP by not including direct groundwater recharge during the snowmelt period in the transient simulations. Addressing this issue is clearly warranted. The lack of an acceptable calibrated transient model is a direct result of how the "approved studies were not conducted as provided for in the approved study plan." There are other problems with the modeling work described in this technical review that also support this finding.

This proposed modification should be adopted because, as previously noted, all sloughs can be regarded as "anomalous," since there is no "normal" or "typical" slough. Slough hydrologic regimes can vary from trickling flows to torrents, from frequent inundations from mainstem flows to rare inundations, or be hydrologically supported by tributary flows or completely lacking tributary flows. They can have robust groundwater upwelling or hardly any at all. These anomalous field conditions make the proposal to "up-scale" the results of the modeling work highly challenging at best, and with a significant likelihood of complete impracticability and technical invalidity of the current approach.

The proposed hybrid approach also recognizes that modeling may be an impractical methodology to perform the needed assessment. Other means of assessment may be needed. The proposed study modification includes the necessary flexibility to incorporate other methods that may be more suitable to the project. Should other methods be proposed, they should be the subject of another modification and thorough review.

As part of the modeling reevaluation proposed in this modification, the strategy of using 2-D transect, 2-D plan view, or 3-D modeling should be reevaluated in light of data collected to date that seem to indicate the presence of complex transient 3-D flow systems that could invalidate 2-D transect modeling, and therefore the entire up-scaling study plan.

Also, consideration should be given to develop a strategy to address winter ice-affected groundwater flow systems differently than summertime flow systems. Considering the seasonality of riparian vegetation activity and life stages of aquatic organisms, different types of analyses may be warranted. For example, simple statistics describing the annual number and duration of peak groundwater levels and trying to relate it to riparian growing conditions may be not significant if most of those peaks occur in the winter as a result of ice backwater effects.

Objective 3: *Assess the potential effects of the Watana dam/reservoir on groundwater and groundwater-influenced aquatic habitats in the vicinity of the proposed dam.*

Methods

The methods for this study component consist primarily of characterizing hydrogeology of the area in the vicinity of the dam site. The ISR indicates that this work will consist primarily of using data collected by other studies, such as the Geology and Soils Characterization study, to develop a conceptual model of groundwater in the vicinity of the dam site. The methods section (ISR 4.3) also states that ground reconnaissance during fall 2013 and LiDAR data will be used to develop information on channel geometry and inundated area of the reservoir. However, the text of the ISR does not explain how these data relate to this study Objectives, specifically, how the effects of the dam and reservoir would affect groundwater-related aquatic habitat. More detailed information is needed to assess whether the methods presented here are adequate to address the study Objectives.

Results

The ISR describes photographs taken during a reconnaissance visit to the dam site in 2013. In the absence of interpretation, these photographs do not constitute results for this particular study element. With the results as presented, it is not possible to determine the status of work towards meeting the goals of this Objective.

Variances

There were no variances for this Objective.

Modifications

NMFS does not recommend modifications at this time. However, since very little work has been accomplished to meet this Objective, they could be needed at a later date.

Objective 4: *Work with other resource studies to map groundwater-influenced aquatic and floodplain habitat (e.g. upwelling areas, springs, groundwater-dependent wetlands) within the Middle River Segment of the Susitna River including within selected Focus Areas.*

Methods

The proposed methodology includes multiple techniques to map groundwater features, including open-lead mapping, aerial photography, thermal infrared (TIR) imagery, and ground-based observations. These are sound approaches to identifying the presence of groundwater upwelling over such an extensive area, in part because the first three methods could be used for joint cross-comparison and cross-validation and are also conducted at different times of the year. These approaches are also appropriate for the spatial scale of interest. The last technique described, ground-based observations, would ideally provide ground-truthing for areas of suspected upwelling. However, the methods for this study element do not describe any such plans.

The final activity for this study element is to "characterize the identified upwelling/spring areas at a reconnaissance level to determine if they are likely to be (1) mainstem flow/stage dependent, (2) regional/upland groundwater dependent, or (3) mixed influence." This is more of an Objective than a method. There are numerous methods that could be used to determine the origin of groundwater discharging to springs and seeps, and this is a topic that has been studied extensively in the hydrology literature. Therefore, more details are needed to determine whether the study plan and implementation are adequate to meet this Objective.

The classification scheme proposed for upwellings/springs as presented may be difficult to implement and less useful than intended. The Susitna River seems to function as a regional hydrologic base level for both surface water and groundwater. Both local and regional flow systems discharge to the river and its sloughs and side channels. Thus, during baseflow (low-flow) conditions, most or all upwellings/springs are likely derived from upland sources or from storage in the alluvial aquifer. During higher flow events, river water enters the groundwater system as bank storage or hyporheic flow, temporarily reversing the direction of flow at some of the upwelling/spring locations. As these high-flow events recede, water reentering the river would be classified as mixed flow. Thus, many sites would be expected to be classified in different categories depending on river stage and antecedent conditions. The details of how upwellings and springs are to be classified are not presented, thus it is not possible to evaluate whether data being collected will be adequate to achieve this Objective. Additional detail of the methods and criteria used for making the determinations should be provided.

The identification and selection of river stage and antecedent conditions may also be an important factor governing the acquisition of imagery for this task.

Recent work (Technical Team Webinar, 12/5/14, slide 53 and other slides) shows the presence of three different regimes: Upland, Transitional, and Riverine in the Susitna River bottomlands. The criteria for differentiating these units are not clearly presented, nor are the boundaries delineated. This may be a useful concept for "upscaling" the results of the groundwater work, however additional work is required to determine whether these units (or some other units) are appropriate for mapping areas adjacent to the river on a larger scale. In reviewing slide 53 for example, these map units may not correlate meaningfully with other resources such as riparian vegetation or aquatic habitat.

As stated in the RSP, one of the work products from study Objective 4, Upwelling/Springs Broad Scale Mapping, is an "analysis of the identified upwelling/spring areas to determine if they are (1) main flow/stage dependent, (2) regional/upland groundwater dependent, or (3) of mixed influence. Given the vast number of upwelling areas already mapped in the Middle Susitna River, this will be a tremendously challenging task. Yet, this work product has received virtually no discussion in the ISR or technical meetings with regard to how it will be accomplished. It is therefore recommended that specific, detailed methods be developed regarding this work product.

Results

ISR Section 5.4 discusses acquisition and processing of TIR imagery [URS and Watershed Sciences Inc., 2013]. TIR imagery flown in October 2012 has been compiled into a mapbook currently available at http://www.susitna-watanahydro.org/type/documents/. This product will be an important component of successfully achieving the Objectives of this study element and is already being used by the Fish and Aquatics In-Stream Flow study in the development of aquatic habitat models [Miller Ecological Consultants and R2 Resource Consultants, 2014].

The proposed methodology of this element includes both air-based and ground-based approaches. Air-based approaches include open-lead mapping and identification of clear water areas from aerial photography. Ground-based approaches include riverbed and streambed temperature monitoring and measurements of vertical hydraulic gradients as part of the Fish and Aquatics In-Stream Flow study. Integrating these multiple data sources would greatly strengthen the reliability of maps showing groundwater upwelling locations on the Susitna River. However, the ISR does not discuss the process of integrating these multiple data sources.

The Final Study Plan (July 2013) states: Results will be provided in appropriate sections of the Initial Study Report. Information resulting from this study component is supposed to include the following:

- GIS map layer of upwelling and groundwater influenced areas;
- Analysis of the identified upwelling/spring areas to determine if they are (1) main flow/stage dependent, (2) regional/upland groundwater dependent, or (3) of mixed influence.

No GIS map layer was provided in the ISR, nor were analyses of upwelling/spring areas presented. The 2015 SIR report states that "differentiating upwelling areas into the three categories will not be possible," (page 15, Section 5.4). There is no elaboration on why the differentiation into the categories identified in the study plan is not possible. The study plans for this task are applicable to the locations of areas in the "Middle River Segment and upper portion of the Lower River Segment that are currently influenced by groundwater inflow."

These three categories are not the same three categories mapped at FA-128 in the 2015 SIR: "Riverine Dominated, Riverine-Upland Transitional, and Upland Dominated." There seems to be a bit of confusion in the terminology and perhaps the methods and results used to identify these different areas. In any event, it seems like it should be feasible to perform differentiation of source with the data sources available. Not performing this activity would be a variance.

A source of data (in addition to those listed) that should be considered to differentiate between different upwelling areas is detailed LIDAR-based topographic mapping. The elevation of upwelling areas above various seasonal high water or flood stages can be a useful parameter in their differentiation.

Variances

No GIS map layer was provided in the ISR or analyses of upwelling/spring areas in broad areas, which is a variance from the study plan.

The mapping of water sources in FA-128 as reported in the SIR uses different categories as specified in the study plans, and this is a variance.

Modification 8: NMFS recommends including an assessment of proposed project effects based on groundwater-influenced aquatic and floodplain habitat maps of the entire river corridor where impacts may occur.

Currently this study objective focus only on preparing maps for groundwater-influenced habitats, but it is not clear if or how these maps will be used to determine impacts from the proposed project. The "Decision Support System" needed for this project should be much more focused on preparing resource-based maps of the river corridor and the creation of "impact zones" based on hypothetical but realistic scenarios of river and groundwater dynamics based on data collected to date, aerial imagery and field-based detailed mapping at a scale of approximately 1:6000 (1 inch = 500 feet), and models of river dynamics based on project operating scenarios.

Resource-based maps should include, for example, detailed geological mapping, vegetation mapping such as is found in Figure 5-32 of the Riparian Instream Flow Study (8.6, SIR, Nov. 2015), aquatic habitat mapping such as is found in Figures 5.6.1, 5.6.2, and 5.6.3 of the Fish and Aquatics Instream Flow Study (SIR, Nov, 2015), groundwater upwelling and groundwater influenced areas. The mapping should consider various stages of the Susitna River such as is found in Figure 5.32 of the Riparian Instream Flow Study (SIR report).

In general, the study has successfully documented that expected riverine and cold climate processes operate in the project area. These processes can be applied to identifiable geomorphic features along with anticipated changes to the riverine environment (including sedimentation and erosion processes) to present the likely range of project effects. The principal outputs of the process could be map based. Then, overall project impacts could be determined by a GIS process of summing areas of different impacts within a suite of categories of impacts. Because of the diversity of environments, this suite of categories should be relatively large. The degree of change in each impact category will be somewhat qualitative, but that may be the best that be done as a practical matter.

The project has embarked on a highly quantified process of attempting to determine impacts with a variety of very complex models that require large amounts of data and assumptions, but which may end up producing results that are less useful than planned. Re-evaluation of these complex models in favor of simpler and less precise but more reliable overall assessments may be in order.

Objectives 5.5 and 5.6 will be reviewed simultaneously and the modifications below apply to both objectives.

Objective 5: *Determine the groundwater /surface water relationships of floodplain shallow alluvial aquifers within selected Focus Areas as part of Study 8.6 (riparian instream flow). The overall goal of this study component would be to collect information and data to define groundwater /surface water interactions and relationships to riparian community health and function at a number of Focus Area locations so results could be used to scale up to other locations in the river. These relationships would then allow for a determination of how project operations may influence groundwater /surface water interactions and the riparian communities at unmeasured areas. Development of physical groundwater models at Focus Areas applicable for evaluating riparian community structure would help to understand the influence of these relationships. Physical models, including surface water hydraulic (1-D and 2-D), geomorphic reach analyses, groundwater /surface water interactions, and ice processes, would be integrated such that physical process controls of riparian vegetation recruitment and establishment could be quantitatively assessed under both existing conditions and different project operations.*

Objective 6: *Determine Groundwater/Surfacewater relationships of upwelling/downwelling in relation to spawning incubation, and rearing habitat (particularly in the winter) within selected Focus Areas as part of Study 8.5 (fish and aquatics instream flow). The same general approach as described above for the riparian component would be used for evaluating groundwater /surface water interactions within aquatic habitats for Study 8.5. Habitat Suitability Criteria and a Habitat Suitability Index would be developed that include groundwater-related parameters (upwelling/downwelling). The Focus Areas for this study component would be limited to those exhibiting groundwater /surface water interactions that relate to the ecology of riparian and/or aquatic habitats pending further evaluation of each of the Focus Areas.*

<u>Methods</u>

These two study objectives, 5 and 6, provide technical support to the Fish and Aquatic Instream Flow Study (8.5) and the Riparian Instream Flow Study (8.6) primarily through installing and operating monitoring stations at the Focus Areas, and through the development of groundwater flow models for the purpose of predicting groundwater levels under project operations.

Monitoring stations established under this study component primarily provide information on groundwater levels and temperatures, and surface water levels and temperatures. There is limited information on soil moisture, soil temperature, and meteorological variables. Time-lapse cameras are deployed at the Focus Areas to assist interpretation of incoming data streams.

Groundwater modeling is a central component of the methods proposed for these two study objectives. The proposed modeling approach entails developing site-specific groundwater models at the Focus Areas. Boundary forcing, primarily stage changes in the Susitna River main channel, will be used to estimate hydraulic properties of the alluvial aquifer. Additional stage change events would then be used to validate the models. There are several challenges with this proposed methodology:

Up-Scaling: The models are described by the RSP as useful tools to scale up the findings of the Focus Areas to unmonitored areas. The focus area differ from each other and from areas below the three river confluence so much that applying groundwater information learned at one location to another may not be possible. Findings previously described from the 1980s studies cast doubt on the viability of this approach. It is not clear how the modeling results will be up-scaled to the broader study area. Focus Areas are all contained in Riparian Process Domains (RPDs) 3 and 4, so it is not likely that the findings would be applicable to domains 1, 2, and 5. Also, within RPD 3 and 4, there are numerous individual vegetative communities and the degree of dependence of these vegetative communities on the water table is not clear. The methodologies for incorporating other factors such as soil type, aquifer lithology, or thickness of the unsaturated zone for which data may be lacking or sparse, are not described. (This issue is addressed with Modification 3 described below Objective 2.)

Water Table Maps: Construction of a 3-D groundwater model is proposed for FA-128. This would normally be based on water table maps constructed for selected time periods for calibration purposes. Construction of water table maps is not an original element of the RSP. However, it has subsequently been incorporated as a work element of the Groundwater Study. Omission of the preparation of water table maps for each Focus Area is a significant flaw of the RSP RVTM which has been partially corrected by the preparation of water table maps contained in the SIR report. Problems with data coverage and quality associated with the maps are discussed subsequently in this technical memorandum.

Winter Conditions: It is also not stated whether the models will be capable of simulating wintertime conditions when aquifers can be locally confined by ground ice, surface ice, or icings. These phenomena are not discussed.

Temperature and Dissolved Oxygen of Upwelling Groundwater: The methodology for understanding future changes in surface and groundwater temperatures and dissolved oxygen is unknown. This is a complex phenomenon under existing conditions and is even more complex under proposed project conditions. The groundwater model as presented does not simulate water temperatures and there is no known bolt-on, post-processor software that would adequately simulate the processes.

Groundwater/surface water Response Functions: The ISR report states: “Task 5 of the Groundwater plan (Study 7.5) centers on defining groundwater/surface water relationships associated with riparian habitats within selected Focus Areas. This task is linked with the Riparian Instream Flow Study (RSP8.6) with one of the objectives being the development of groundwater /surface water response functions for different locations within a Focus Area that can be used to assess upland-dominated groundwater from riverine dominated groundwater /surface water interactions resulting from different Project operational scenarios.”

It is not clear what a "groundwater /surface water response function" is or how they will be developed and used to assess the effects of different Project operational scenarios. This section is confusing and should be clarified and defined.

2D vs 3D Groundwater Flow Systems and Models: As a general guide to 2D transect models, Anderson and Woessner (2002) state that "the main consideration in orienting the profile is to align the model along a flow line"... so that all flow in the model occurs "parallel to and in the plane of the profile." Field situations in which this is not done introduce errors into the modeling process that should be recognized and addressed with respect to the purposes of the modeling simulations. Previous hydrologic studies [e.g. Loeltzand Leake, 1983; Nakanishi and Lilly, 1998; Arihood and others, 2013] confirm this concept.

For example, Nakanishi and Lilly [1998] (cited in the FERC Study Plan Determination as a template methodology for this study) used a 2D transect model along the Chena River, Alaska, and found it necessary to use a "30 percent adjustment for geometry effects" to account for the three-dimensional nature of the flow system caused by the river's large meander. In the Focus Areas, local surface water geometries are far more complex. Examination of multiple Focus Area water table maps shows that inferred directions of groundwater flow are commonly not aligned with the planned profile models, which should cause reevaluation of the adequacy of the planned 2D modeling to simulate conditions in real-world three-dimensional transient groundwater flow systems.

One of the stated Objectives of the modeling is to simulate the effects of sudden rises or lowering of river stage. These changes may be caused by river ice processes, natural flooding processes, or future dam operations and are an important part of the groundwater analysis. If water levels in the mainstem suddenly rise for example, the groundwater flow directions (in plain view) will likely change in a manner that cannot be simulated with a 2D profile model. Errors introduced by this transient situation should be addressed, especially as it pertains to simulating water-level changes caused by proposed dam operating scenarios.

These analyses call into question the validity of the key assumptions underlying the use of 2D transect models for Focus Areas on the Middle Susitna River. Compelling evidence for this approach has not yet been presented and this approach may not be adequate to meet the Objective for this study element.

In some situations, the most appropriate modeling exercise would be to construct a 2-D plan view model rather than a 2-D transect model. The distribution of water-table data and surface water geometries for use in calibrating the model at many of the Focus Areas appears to be better suited to a 2-D plan view analysis rather than a 2-D transect analysis. In some cases, there may be advantages to performing both types of analysis in order to achieve project Objectives.

Local Recharge: The modeling work describes simulating hydraulic head pulses from changing river levels, but the water table is also influenced by local recharge events at the sites of the monitoring wells and from up-gradient areas. Rain gages were installed, however the study does not discuss how the data and the accompanying soil moisture and water table data will be used in the modeling work to simulate the effects of local rainfall and snowmelt on fluctuating water tables. These rainfall and snowmelt events could affect water levels in these shallow aquifers on the same time scale as rising-river levels (minutes to hours). The absence of snow survey data to inform groundwater recharge estimates during the spring snowmelt is another significant limitation of the methodology.

Vertical Groundwater Gradients: Another potential limitation with the design of the groundwater modeling effort in this task is that vertical gradients within the aquifer were not measured. The comparable study cited (Nakanishi and Lilly, 1998) had multiple nested observation wells with which to calibrate the model to deeper parts of the flow system. Since these are lacking in this study, the model will only be able to be calibrated and verified for the surface of the aquifer. Thus, the transect model of Nakanishi and Lilly (1998) is only generally, not entirely, similar. If there is no water-level information at depth to guide model calibration, the modeling work, in effect, becomes more of a 1-D calibration exercise, possibly with a distributed recharge component, a variable thickness aquifer, and boundary conditions.

Assessment of Geomorphic River Channel Changes: The methods described do not address the effects that potential changes in river geomorphology - either aggrading or degrading streambeds, could have on the system. Any thorough groundwater model-based assessment of the project effects on groundwater levels and aquatic or riparian habitat should consider the effects of this phenomenon. For this reason NMFS requested a new Study on Model Integration

Icings: There is no discussion of the potential for groundwater levels to rise during the winter as a result of icings (the freezing of discharging groundwater into large masses of ice that partially "dam" groundwater and cause the water table to rise). This is a well-known phenomenon in cold regions and should have been addressed as a potential cause of the some of the observed water-level rises. The process of icings and observations about their occurrence and extent (if any); especially in the focus areas, should have been included in the groundwater study.

In summary, the methodology for analysis of the data is not presented in enough detail to determine whether the Objectives will be met, however the identified shortcomings of the methodology casts significant doubt that the 2-D modeling proposed would be technically valid and accomplish the project Objectives.

<u>Results</u>

Temperatures and Dissolved Oxygen of Upwelling Groundwater: There is no data or analysis about understanding the temperature or dissolved oxygen of upwelling groundwater under project operating conditions. These are key aquatic habitat parameters that should be addressed in the groundwater study. The suggestion that this can be evaluated with model output is vague and peculiar considering that MODFLOW that does not simulate thermal properties of water and aquifers.

FA-128 Groundwater Model: The preliminary three-dimensional groundwater model at FA-128 has significant conceptual and technical shortcomings that are discussed in the following section.

1. Sparse and Limited Areal Coverage of Data and Data Quality

The feasibility of constructing 2D or 3D models at most Focus Areas in order to provide the inputs planned for the riparian and aquatic habitat analyses and the up-scaling process is significant hampered because of insufficient and questionable data. The water table maps at all of the Focus Areas except FA-128 have very sparse spreads of monitoring stations with which to draw water table maps and construct 3D groundwater models. Groundwater contour lines are short and discontinuous and large areas of the Focus Areas are devoid of data and contours, including at important sloughs. The original plan was to construct profile models along linear orientations perpendicular to the river; however this is likely to not be viable. Since this was previously commented at the October 2014 technical meetings and December 5, 2014, webinar, AEA has not further addressed this concern or clarified how it plans to model these Focus Areas in the future. As a result of these issues, the feasibility of constructing 2D or 3D models in order to provide the inputs planned for the Riparian and aquatic habitat analyses and the up-scaling process is in significant doubt.

There are numerous anomalous data reported on the water table maps that are omitted from contouring based on "professional judgment" (SIR Appendix A-Page 3, Section 4, Methods). Item-by-item, these should be further evaluated with descriptions of exclusion criteria and discussion regarding possible hydrodynamic influences on the data, unresolvable data errors, or other causes. Any "lessons learned" should be incorporated into future data collection efforts to ensure that a robust set of groundwater and surface water data are usable for the time periods of interest in the groundwater analyses.

The Groundwater Study has made data available from project monitoring wells, including groundwater levels and temperatures at http://gis.suhydro.org/reports/isr. Two critical pieces of information that have not been provided are the well depth and lithology. It is standard in hydrogeologic investigations to provide records of both when reporting results. Obviously, well drive points do not provide lithology data, however data from other sources such as the 1980's studies and shallow soil investigations conducted under other studies should be used to characterize the subsurface. The interpretation and groundwater modeling proposed as part of this study is limited without these data, and it is difficult for reviewers to interpret data from the groundwater stations without also having knowledge of well depth and lithology. Therefore, it is recommended that these data be made available along with other monitoring station data, and be explicitly included as appendices or figures in future reports.

2. Unsuccessful Transient Calibration

Table 5.1 presents calibration statistics which make appear like the model matches the field data, however the process for arriving at calibration statistics requires further explanation. The model predictions for groundwater wells that are close to surface water measurements match well, however those that are 200 meters from open water do not match well at all. Was the analysis inadvertently biased by the 12-hour quasi-steady state periods of time prior to and after the river stage pulse compared to the time period of rapidly changing pulse? One of the major purposes of the transient model is to simulate the river pulse dynamic, and a qualitative review of the most dynamic portions of the curves for FA128-4, FA128-5, FA128-6, FA128-7, FA128-11, FA128-13, FA128-21, FA128-26, and FA128-27 on Figures 5-5, B1-3, 5-6, 5-7, 5-8, 5-9, B1-10, B1-14, and B1-15 show that the model fit to the data look rather poor. This is a relatively large number of curves that appear not to be well-simulated by the model's dynamic river pulse. It should be better explained why the apparent fit for FA128-13 appears to be rather good on Figure 5-3 and rather poor on Figure 5-9. A few of the targets have relatively well-fitting curve shapes, but they are offset by a significant amount that may be explainable by approximations in the river stage modeling scheme. While one of the major purposes of the transient simulation was to simulate the river pulse, the relatively poor and anomalous fitting of numerous data sets merits closer evaluation. Re-evaluation of the model calibration statistics for the transient run and a more thorough analysis is needed to verify the findings before concluding that the calibration statistics "were relatively good" (as readers might infer incorrectly that the calibration is relatively good).

During the March 23, 2016 meeting, it was noted that the method for determining calibration statistics for the transient run should be reevaluated. Mr. Swope stated that they did not calculate calibration statistics for the transient calibration. This is an incorrect statement. Table 5.1 of the SIR shows that the Root Mean Square Error (RMSE) for the transient run is listed as 9.6%. The modeling report makes clear that the transient model is not properly calibrated. This is likely because:

1. Model parameters aquifer storativity and regional groundwater recharge were given potentially unrealistic values in an attempt to make simulated water levels match measured water levels;
2. An important process was not incorporated into the model formulation, that of direct groundwater recharge from snowmelt; and
3. Measurements of flow in sloughs attributable to groundwater discharges should be important groundwater model calibration targets, but were not used.

These topics are described in additional detail below.

<u>Direct Groundwater Recharge from Snowmelt</u>

There is a potentially major conceptual flaw in the MODFLOW groundwater model based on the conclusion that "...the hydrologic response is exclusively related to increases in river stage..." Surprisingly, the model fails to simulate or even acknowledge the process of on-site snowmelt recharge to the water table to raise water levels in observation wells completely distinct from any changes in river stage. Springtime increases in groundwater levels from snowmelt are commonly in the range of a few feet, which is of a similar magnitude as increases caused by increases in river stage. With all of the data available at this site, the model should have incorporated direct recharge from snowmelt into the analysis. Without doing so, the comparisons of transient model head values with measured head values presented as a measure of goodness of calibration of the model is relatively meaningless. This conceptual shortcoming undermines the validity of the entire modeling process to date.

Annual precipitation in Alaska is commonly divided into three major components: evapotranspiration, surface runoff and groundwater recharge. For this model to assign a value for groundwater recharge based only on the difference between annual precipitation and pan evaporation without further explanation is a potentially significant conceptual problem in the structure of the model. Also, recharge tends to be highly seasonal in this area, with most recharge occurring during the fall rainy season or spring snowmelt season with additional recharge from significant summer storms. The steady state period simulated, May 20 to June 6, is described as being "...stable with little flooding or precipitation...," (Appendix B-Page 10), which raises questions whether the relatively high groundwater recharge rate simulated is characteristic of the steady-state period simulated. This needs further explanation, evaluation, and revision.

There is also a significant data gap. There appears to have been no snow survey data collected at this site. Snow survey data collected near the end of winter captures the water content of the snowpack and thus informs estimates of groundwater recharge during the snowmelt period. Because the transient period selected for hydrologic pulse simulation is the snowmelt period, these data would have been important for evaluating the local snowmelt recharge in causing water-table rises and their absence creates uncertainty about the modeling.

Regional Groundwater Flow

The fluxes of groundwater into the modeled region along the sides of the model (representing regional groundwater flow inputs to the modeled area) were reduced by an order of magnitude in order "to improve the overall calibration." This requires further justification and analysis prior to acceptance of it into the model. This parameter was the result of prior estimation of these fluxes, which have not been demonstrated to be flawed, and is a very large deviation from those estimates. This parameter should not be treated as an adjustment parameter on a black box model that can be adjusted to values that simply seem to make the model work better.

Analysis of the "Groundwater regional scale relationship to local flow systems" should include additional evaluation of the early 1980's estimate of fluxes of 2.1 ft^2/d from regional groundwater flow towards the Susitna River compared to the models use of 0.21 ft^2/d for the flux at FA-128. As part of this evaluation, the model's application of a recharge rate of 10.5 inches/year should be compared to average regional recharge rates that would reflect the different regional flux estimates towards the river.

The SIR modeling text is dismissive of estimates by 1980's studies of the regional groundwater flux towards the Susitna River (2.1 ft^2/day) based on "regional aquifer properties, gradients, and thicknesses, but not empirical data." The authors present no basis for their current 0.21 ft^2 /day parameter, which is an order of magnitude lower. The regional information used to determine the prior estimates are "empirical data" and should not be so readily dismissed in favor of the model-derived parameter. The authors do not consider that the unusually low model-derived parameter could be an artifact of some other approximation or problem with the model. This should be reevaluated during any future attempts to calibrate or validate the model.

<u>Aquifer Storativity</u>

The model also tweaked values of aquifer storativity as a calibration parameter of the model. The value they ended up with is characteristic of confined or semi-confined aquifers, not a water table aquifer, like the rest of the report describes. This is a very large unexplained technical shortcoming.

The text states: "The storage coefficient was initially set to 0.2, but was eventually reduced to a value of 0.001 to achieve a better match to the observed groundwater elevation response. This value is somewhat low for an unconfined aquifer and may suggest the aquifer is semi-confined." This is anomalous in consideration of the fact that the aquifer "is assumed to be a water table aquifer" and abundant data and prior reports show that it is. Freeze and Cherry (1979) describe aquifer storativity as having a "usual range" for unconfined aquifers of 0.01 to 0.3. The modeled value is a full order of magnitude below the lower bound of the usual range.

This parameter adjustment should be vetted against other data, such as geological information about the nature of the aquifer, well construction information, depth of frost penetration, and backhoe pits and aquifer tests that were performed in the 1980's. This parameter should not be treated as an adjustment parameter on a black box model that can be adjusted to values that seem to make the model work better. Such a deviation from values typical for a water table aquifer suggests that there may be one or more fundamental undiscovered problems with the model.

<u>Groundwater Discharge to Sloughs</u>

The steady state model is described as simulating a period of time when side channels are predominantly fed by groundwater. These side channels and sloughs have been the subject of considerable study, including discharge measurements of channels that have no headwater connection to the Susitna River. At the same time, these channels represent one of the major applications of the entire modeling exercise for evaluating changes to aquatic and riparian habitat in these areas. Thus, it would seem that flow data (specifically, groundwater upwelling fluxes into the side channels or sloughs) should be a calibration target in addition to head data. The model should be explicitly simulating flow to these side channels, and if it isn't, the grid spacing should be refined enough to do so. This would be one of the best ways for the model to fulfill its potential, to be able to simulate changes in water quantity and temperature in side-channels and sloughs in response to potential future project operations. Without using these side-channel flow data as calibration targets, it may be impossible to determine the reliability of future groundwater flow models and the knowledge gained from the valuable fieldwork measuring side-channel and slough flows will have not have been used to its full potential.

In Summary, the studies fail to prove that calibration and verification of a three-dimensional groundwater flow model is possible, even in the best-instrumented Focus Area (FA-128). Considering the poorly understood system response to present and future short-duration hydrologic events and other limitations noted above, the studies to date create significant doubt that project Objectives are achievable with the current methodologies and progress of work.

<u>Variances from the Revised Study Plan</u>

Data should have been provided on well depths and open intervals. This is a standard component of groundwater studies as described by the references to the FoSP and is a variance.

Technical reports to date presume that the groundwater flow model can be fully calibrated and validated. This has not been demonstrated to be achievable; therefore the assertion that the method will provide predictive simulations to evaluate the effects of different project operational scenarios is unconfirmed and is a variance from the study plan. Also, the application of the methodology to other Focus Areas with fewer data or to other reaches of the Susitna River without any detailed data are not addressed and is also a variance.

Modification 2: NMFS recommends including the acquisition of field data and improving the current performance of surface water/groundwater models to be able to simulate short-duration fluctuations in surface water/groundwater interactions characteristic of future proposed project operations at each Focus Area.

The current groundwater modeling effort is not capable of simulating fluctuating groundwater/ surface water interactions at short-duration time scales (hourly) that will be characteristic of proposed project operations, nor does it appear likely that it will be capable of modeling such events during the course of the approved study. This is a major limitation of the model and a variance from the approved plan to model groundwater to simulate such pulses. Approved studies were not conducted as provided for in the approved study plan.

"Short duration temporal variations" can occur "in response to the various hydrologic events" (SIR study), such as precipitation, ice dams, river rise, or snowmelt. Analysis of these types of events is extremely challenging, and the averaging procedures used in the SIR study, such as 12-hour time steps, were not sufficiently detailed to capture the responses of the groundwater system to these types of events, likely contributing to some of the anomalies that resulted from the studies. This is important because the Project is also expected to produce significant short-duration temporal variations in flow (hourly and daily) that will not be well understood without additional work identifying the responses of the natural system to these short-duration events.

The Project will affect Susitna River flow on a seasonal, daily and hourly basis and will affect downstream resources/processes including ice dynamics, channel form and function, water temperature, and sediment transport. These changes have thus far not all been incorporated into the groundwater model and associated other models such as Open Water Flow Routing Model (OWFRM) and the 2D Physical Habitat Simulation (PHABSIM) models that are needed to assess project impacts. ‘Proof of Concept’ is not complete until the models can be demonstrated to adequately simulate and predict the effects of all of these physical phenomena.

The authors of the SIR groundwater modeling report describe the complexities of analyzing short-duration hydrologic events. It is not clear if there are adequate data available to analyze these phenomena. Frequent and synchronous data on river stage, groundwater levels, precipitation and snowmelt may be required and portions of the datasets appear not to have been collected during critical times to conduct robust analyses. Part of this study modification would be to perform a data needs assessment and take steps to make sure that adequate data are available.

Modification 4: NMFS recommend that in a single Pilot Scale area, AEA should demonstrate that the various models can interact to produce useable data with realistic error bars (Objective 5 and 6).

This request is refined and justified in the Model Integration New Study Request and will not be discussed here.

Modification 5: NMFS recommends evaluating changes in groundwater temperature and dissolved oxygen from proposed project operations

The temperature and dissolved oxygen content of upwelling groundwater are important factors influencing aquatic habitat. There appears to be no task or Objective in the groundwater study for evaluating changes in these parameters under proposed operating scenarios, even using non-modeling techniques. MODFLOW, the only groundwater model proposed, does not simulate these parameters. The importance of this topic is indicated by the fact that a two-dimensional heat-flux/groundwater flow model was constructed during the 1980's studies.

Unless this topic is adequately covered in other studies, this represents a significant gap in the FERC-ordered study plan and a modification of the plan should be made in order to address this important process.

Modification 6: NMFS recommends assessing the current and future flows that will be required to breach the head-of-slough barriers to meet Objective 6.

The effects of overbank flow, breaching flows over head-of-slough sediment barriers, and flow in side channels of the braidplain in the lower river area are significant drivers of groundwater levels, however appear to be unevaluated and are not apparently included in the groundwater and surface water studies to date.

In the lower river, a comparison of proposed flows and natural flows show that there would be fewer and lower high-flow events that would inundate side channels and recharge groundwater under project operations. The absence or reduced frequency and peak of these high flows could lead to the condition found in many other dammed river systems that the water table generally becomes lower in response to dams. This persistently lower water table can then result in establishment of different vegetation regimes (like spruce and birch) that are better adapted to persistently lower water tables and reduction of aquatic habitat.

In the Middle River segment, many sloughs are headed by sediment berms. When these are overtopped, it is expected that there would be a relatively quick and substantial impact on groundwater levels near the slough. The later recession of river levels would then be followed by much slower returns of groundwater levels to lower levels. Similarly, low bars and islands could be overtopped, also leading to groundwater recharge. In response to a question at the March 2016 session on Groundwater, investigators appeared to have little information about this process as it applied to the transient groundwater model.

A modification of the groundwater study should be initiated that would further evaluate overtopping phenomenon (especially changes that would occur under project operations) throughout the river corridor and its effects on groundwater levels and riparian and aquatic habitat. Groundwater modeling studies as described by the modeling methodologies cited in the approved study plan all require that boundary conditions of a model reasonably simulate field conditions, including overtopping. This modification is warranted on the basis that the approved studies were not conducted as provided for in the approved study plan. Also, the overtopping or breaching of surface water should be regarded as an anomalous or changed field condition, and this modification is warranted on the basis that the study was conducted under anomalous environmental conditions or that environmental conditions have changed in a material way.

One possible tool for this evaluation that should be considered is inundation mapping using existing LIDAR topographic mapping and flood stage modeling. Such an analysis can characterize the existing frequency and extent of inundation with projected future inundation under project scenarios. These characterizations could then be used to evaluate groundwater responses and impacts to habitats.

Modification 7: NMFS recommends the collection of snow survey data at representative Focus Areas.

The current groundwater modeling efforts are hampered by a lack of key data for simulating direct groundwater recharge during the spring snowmelt period. This is critical because this is the time period that was selected for the transient modeling work. A snow survey should be conducted during late March or early April before significant seasonal snowmelt occurs in order to establish appropriate transient groundwater recharge rates for the model.

Standard groundwater modeling methodologies as cited in the approved study plan are clear that appropriate data should be used to establish groundwater recharge rates for transient model simulations where recharge is an important process. This justifies approval of this study modification because "approved studies were not conducted as provided for in the approved study plan."

Modification 9: NMFS recommends that additional water table data must be collected to provide sufficient spatial and temporal distribution of water table data in Focus Areas other than FA-128. In all other Focus Areas too few wells were monitored for too short a time period.

It is apparent from inspection of the water table maps for all of the Focus Areas except FA-128 that most of the groundwater data collection-stations are aligned along a single transect perpendicular to the river. This clustering of data makes for a poor water table map, which is key for three-dimensional or two-dimensional plan view groundwater flow modeling. As part of this proposed modification, a data needs assessment should be performed to optimize data collection for periods of time that will be simulated by the models.

As previously described, two-dimensional transect modeling is generally not appropriate for the

Focus Areas because of up-valley or down-valley components of groundwater flow that cause significant inaccuracies in the models. Standard groundwater modeling methodologies as cited in the approved study plan provide that transect models should be aligned parallel to groundwater flow directions. This justifies approval of this study modification because "approved studies were not conducted as provided for in the approved study plan."

Modification 10: NMFS recommends including the effects of aggrading or degrading channels or other channel changes on groundwater and associated habitats to meet Objective 6. (If the New Study Request for Model Integration was accepted, it would also cover this modification.)

The effects of the project on the geomorphology of the river (aggrading, degrading channels or other channel changes) and consequent implications for groundwater and habitats needs further development and inclusion into the groundwater study. Current groundwater modeling uses only current river channel configurations and stage for defining model boundaries. If channel down-grading or aggradation or other changes occur, this will affect groundwater. Evaluation of this effect is currently not part of the groundwater study, but it should be. Such changes in the river would mean that the current modeled conditions would be considered anomalous compared to future conditions, thus justifying this modification.

Modification 11: NMFS recommends the installation and measurement of vertical groundwater gradients through nested observation well pairs to meet Objective 6.

The SIR report failed to identify the variance of not having installed nested monitoring wells to measure vertical groundwater gradients. The lack of nested wells and measurement of vertical groundwater gradients hampers understanding of local and regional groundwater flow system relationships. The RSP states that nested wells and shallow wells in surface water habitats will be installed as part of Objective 6, however these were not installed.

The RSP also states that simulated hydraulic gradients will be compared to observed hydraulic gradients as part of Objective 6. Without collecting data on vertical hydraulic gradients, it will not be possible to complete this analysis. It is recommended that field efforts be undertaken to get the wells in place as soon as possible.

Approved studies were not conducted as provided for in the approved study plan.

Objective 7: *Characterize water quality of selected upwelling areas that provide biological cues for fish spawning and juvenile rearing in Focus Areas as part of Study 8.5. At selected instream flow, fish population, and riparian study sites, basic water chemistry data (temperature, dissolved oxygen, conductivity, pH, turbidity, redox potential) would be collected that define habitat conditions and characterize groundwater /surface water interactions. Water quality differences would be characterized between a set of key productive aquatic habitat types (three to five sites) and a set of non-productive habitat types (three to five sites) that are related to the absence or presence of groundwater upwelling to improve the understanding of the water quality differences and related groundwater /surface water processes.*

Methods

Point-in-time water-quality data collection in the Focus Areas was conducted as part of the Baseline Water Quality Study; the sampling methods are described in ISR section 4.4.2. The Baseline Water Quality ISR shows the locations of water quality sampling transects at the Focus Areas. The surface water transects are located primarily in the Susitna River main channels and side channels. In addition, point samples, and in some cases, depth profiles, were collected in select off-channel habitats. Finally, groundwater wells were installed specifically for the purpose of water quality sampling at FA-104, FA-113, and FA-128. At each site, basic water quality parameters, including water temperature, dissolved oxygen, pH, specific conductance, turbidity, and redox potential, were collected every 2-3 weeks during the open-water period of 2013.

The objective for this particular Groundwater Study element was to characterize water quality of selected upwelling areas that provide biological cues for fish spawning and juvenile rearing. Assessing whether the study methods are adequate to achieve this objective entails assessing whether upwelling areas included adequate sampling points. The Focus Area water quality sampling locations shown in figures 4.4-2 through 4.4-8 of the Baseline Water Quality ISR represent a relatively small subset of possible upwelling location within the Focus Area.

To illustrate this point, figures 1a-d (Section 5.0, this document) compare the locations of water quality sampling locations within FA-128, to areas of potential groundwater upwelling identified using both TIR data and streambed vertical hydraulic gradient measurements. Figure 1a is taken from the Baseline Water Quality ISR [URS and Tetra Tech, 2014]; Figure 1b is taken from the October 2012 TIR Mapbook [URS and Watershed Sciences Inc., 2013]; and Figures 1c-d are taken from a presentation [GW Scientific, 2014] delivered at the Riverine Modeling Proof of Concept meeting in April 2014. Comparison of the figures shows numerous zones of groundwater upwelling that do not coincide with water quality sampling locations.

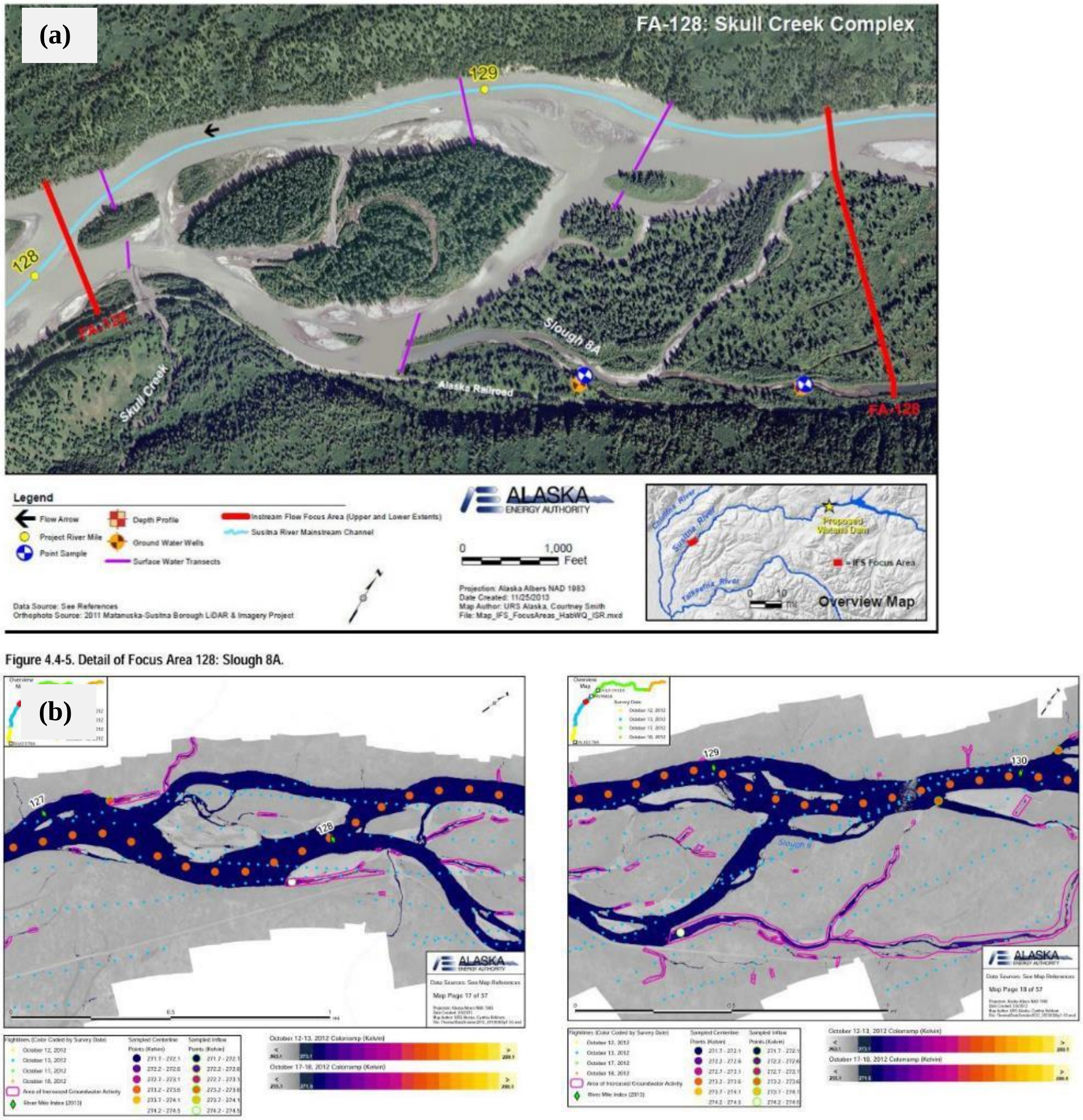

Figure 1. Comparison of water quality measurements and upwelling areas at FA-128. (a) Location of surface water quality measurements, (b) zones of possible groundwater influence identified from TIR imagery, (c & d – next page)

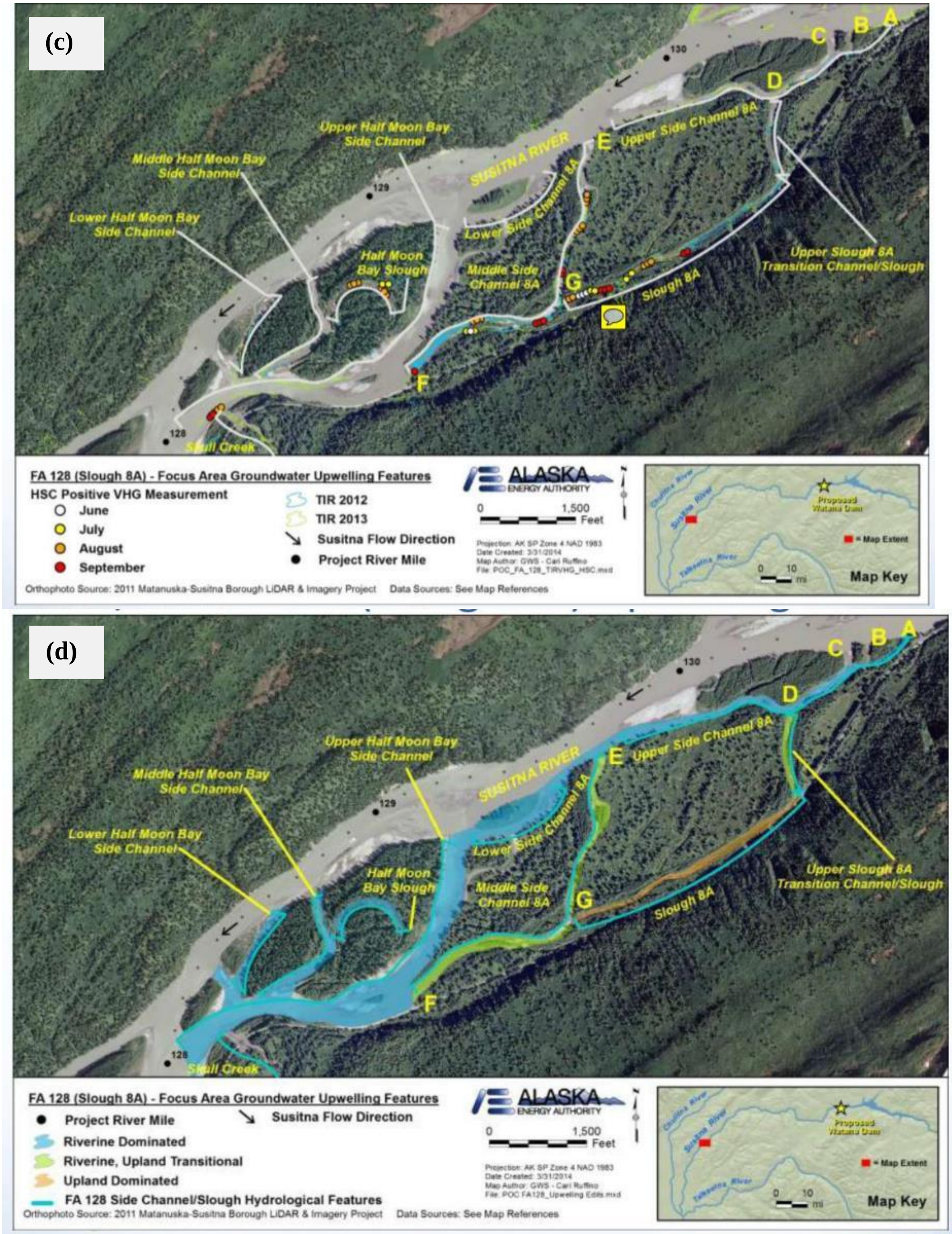

Figure 1c & 1d. Comparison of water quality measurements and upwelling areas at FA-128. (c) locations of positive (upward) vertical hydraulic gradient measurements during 2013, and (d) preliminary characterization of upwelling areas.

The purpose of this comparison is not to argue that water quality samples are needed for each and every area of groundwater upwelling. Instead, it should be noted that the locations of water quality sampling points probably do not completely bracket the range of conditions in the Middle River with respect to groundwater/surface-water interactions. For example, comparison of figures 1a and 1d shows that in FA-128, the water quality sampling locations (both point and transect) are located in zones delineated as "upland dominated" or "riverine dominated." However, comparison of figures 1c and 1d shows that positive vertical hydraulic gradients were measured in numerous locations in zones delineated as "riverine, upland transitional." These areas do not include water quality sampling locations. In order to address the objective of this study element, it may be necessary to revisit sampling locations based on field data collected in 2013, to ensure that water quality sampling brackets the full range of groundwater-surface water conditions in the Focus Areas.

Results

ISR Section 5.7 discusses temperature monitoring data recorded at groundwater, surface water, and streambed monitoring stations operated under the groundwater study. In general, the streambed temperature monitoring stations were sited in or near upwelling areas thought to be important for different fish life stages. Therefore, these data appear to directly support the study Objective of characterizing water quality of selected upwelling areas of biological importance.

The methods outlined in ISR section 4.7 rely heavily on the efforts of the Baseline Water Quality Study for the purposes of determining field parameters other than water temperature, such as dissolved oxygen, pH, and conductivity. Raw water quality data collected at the Focus Areas under the Baseline Water Quality study have been made available through AEA at http://gis.suhydro.org/reports/isr. These data show that for the surface and groundwater quality monitoring sites selected, the selected water quality variables were collected.

Variances

Groundwater models are listed as a work product for this study element, in FERC Study Plan Determination. However, the text of the FSP (section 7.5.4.6) does not describe groundwater modeling and what role, if any, groundwater modeling would have in completion of the study objective.

Modifications

No modifications are recommended to Objective 7.

Objective 8: *Characterize the winter flow in the Susitna River and how it relates to groundwater /surface water interactions. Water levels/pressure would be measured at the continuous gaging stations on the Susitna River during winter flow periods. Winter discharge measurements would be used to help identify key sections of the mainstem with groundwater baseflow recharge to the river (upwelling). In Focus Areas, channel/slough temperature profiles would be measured to* *help characterize the groundwater /surface water interactions and temporal variations over the winter flow season.*

Methods

Section 4.8 of the ISR points out that the hydrologic monitoring stations installed as part of the Groundwater study operate year round. Similar to study objectives 5 and 6, this is a study objective for which the availability of continuous hydrologic data will be critical. The monitoring network currently deployed at the Focus Areas appears to be generally suitable for addressing the Objective of this particular study element. One item described in ISR section 4.8 requires further clarification. Paragraph 3 states that “winter discharge measurements will help identify key segments of the mainstem with groundwater baseflow recharge to the river (upwelling).” These kinds of measurements, referred to either as “synoptic differential discharge measurements” or more commonly, “seepage runs”, represent a sound approach towards characterizing reach-scale groundwater/surface-water interactions. However, successful implementation relies on also measuring tributary inflows along the study reach, and performing the discharge measurements spaced as closely (in time) as possible. These are two critical considerations of successfully performing a seepage run that should be discussed in the methodology but are not.

Results

It is not clear exactly what groundwater study work products are specified by the FSP. It appears that several items (such as discharge measurements) are items that will be conducted by others and may be reported elsewhere. Also, there appears to be no work product providing for the interpretation and analysis of data.

Only selected data was provided in the ISR and this appears to be a variance from the FSP, which appears to call for a more thorough presentation of data. The ISR does however; contain some analysis and interpretation of data, which exceeds the expectations, set by the FSP.

Data report in the ISR includes data that are used to identify important wintertime process, such as ice-jam flooding in the mainstem and seasonal temperature variations. In general, these processes are well known and the data serves to demonstrate that they occur in the Susitna River basin. The data also serve to quantify the specific events observed at the sites monitored. What is unclear is how representative these data are of unmeasured sites. There could be challenges in this project to "up-scale" the findings to the broader study area.

ISR Section 5.8 provides examples of how time-lapse photography aids the interpretation of continuous groundwater and surface water level data during the ice-affected period. Specifically, time-lapse photos document ice formation and accumulation, and help to explain variability in groundwater and surface water levels and temperatures. The results here do not fully address the objective of this particular study element: to characterize the winter flow in the Susitna River, and its relation to groundwater /surface water interactions. This is because only off-channel photos of ice cover are analyzed.

One key question, perhaps falling more under the purview of the Ice Processes Study, is the relation between discharge and ice cover in the mainstem to ice processes and groundwater /surface water interactions in the off-channel habitats. This question could be addressed by comparing the evolution of ice cover using time series from multiple cameras. An example would be to usethe results in ISR section 5.8 use images from stations ESCFA 104-22, looking out through slough 3B into the main channel. These images could be compared to the time-lapse images collected at ESCFA104-19, ESCFA 104-17, and ESCFA 104-18, to show the progression of ice movement into the off-channel habitat. This kind of data interpretation would more clearly relate flow in the river to groundwater /surface water interactions in the off-channel habitats, using data that are already available.

Variances

There are no variances outside of a delayed schedule.

Modifications

No modifications are recommended to Objective 8.

Shallow Groundwater Users

Objective 9: *Characterize the relationship between the Susitna River flow regime and shallow groundwater users (e.g. domestic wells).*

Methods

Section 4.9 of the ISR lists a proposed approach to assess potential project impacts on shallow groundwater users. The approach includes monitoring groundwater levels and temperatures in domestic wells near the Susitna River, conducting an inventory of wells in Alaska Department of Natural Resources and U.S. Geological Survey databases, and scoring the vulnerability of those wells to changes in the hydroregime of the Susitna River. The latter task will draw upon ASTM D6030, "Standard Guide for Selection of Methods for Assessing Groundwater or Aquifer Sensitivity and Vulnerability," [ASTM, 2008b].

The Alaska Department of Natural Resources and USGS databases are likely deficient in identifying most of the wells close to the Susitna River, unless prior studies have performed detailed inventories. In remote areas such as this, the percentage of wells with entries in either database is typically low. Other means should be employed, including air photo interpretation of likely structures with wells and field inventories of wells.

Results

The ISR reports that data for shallow groundwater users are available on-line, however they could not be found during this review. In any event, there is no analysis of the data.

The well data collected in the Middle River Segment is extremely limited compared to the geographic area of the Lower River segment and the diversity of riparian vegetation there. For example, the wells are located outside of the active floodplain and groundwater data are not representative of active floodplain riparian vegetation environments. It is not clear how the limited groundwater data set would provide an understanding of how Project operational changes may influence riparian vegetation.

Variances

There are no variances outside of a delayed schedule.

Modifications

No modifications are recommended to Objective 9. Future modifications could be needed once some products have been produced.

Summary of Technical Reviews

Overall, the groundwater studies lack clear direction and methodology. Data collections efforts at FA-128 may have enough spatial coverage, but there appear to be issues with anomalous data vales. At all other Focus Areas there simply is not enough groundwater data to construct a water table map or a 3-D groundwater model.

The groundwater modeling effort varies from common practices, inserting considerable potential error and uncertainty into the modeling processes. As a result, it is not clear that the models will be useful for the intended purposes. Sources of information are distributed throughout other studies, which presents a disjointed effort to review and understand the studies.

With many study elements incomplete, some with almost no results reported, insufficient data and methodological descriptions are presented to determine whether study Objectives can be met in the future. It is clear that overarching study objectives have not been met at this time.

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7.6 Ice Processes

ISR Review and Study Modifications

The National Marine Fisheries Service (NMFS) review of the Ice Processes Study is a compilation of previous reviews of the ice processes including the following documents and meeting notes (partial list):

- Revised Study Plan (RSP), December, 2012;
- Federal Energy Regulatory Commission's (FERC) Study Plan Determination (4/1/2013);
- Initial Study Report (ISR), June, 2014;
- Detailed Ice Observations TM, September, 2014,
- Alternate Visualization of Freeze-up Progression TM, September, 2015;
- 2014–2015 Study Implementation Report (SIR) (October 2015).
- Riverine Modeling Integration Meeting (November 13–15, 2013);
- IFS-TT: Riverine Modeling Proof of Concept Meetings, April 15–17, 2014,
- Initial Study Report Meetings, October, 2014 and ISR Meeting (3/24/2016).

Study Objectives

The study objectives in the Revised Study Plan (RSP) as stated in FERC Study Plan Determination (4/1/2013) are:

1. Document the timing, progression, and physical processes of freeze-up and break-up during 2012–2014 in the Upper River, Middle River, and Lower River segments using the following methods: historical data, aerial reconnaissance, stationary time-lapse cameras, and physical evidence.
2. Develop a predictive ice, hydrodynamic, and thermal model of the Middle River for existing conditions using the River1D17 (sic) model to simulate time- variable flow routing, heat-flux processes, seasonal water temperature variation, frazil ice development, ice transport processes, and ice-cover growth and decay. The model would be calibrated as an open-water model using known discharge events and then verified using pre-project ice data from the 1980s and data collected as part of the study for a range of climate conditions.
3. Use the River1D model to simulate conditions in the Middle River due to various project operating scenarios and predict changes in water temperature, frazil ice production, ice cover formation, elevation and extent of ice cover, and flow hydrograph. The model would also predict ice cover stability, including potential for jamming, under load-following fluctuations. For the spring melt period, the model would predict ice-cover decay, including the potential for break-up jams. Proposed operating scenarios would include, at a minimum, the load-following scenario described in the Pre-Application Document (PAD) and a base-load scenario.
4. Develop detailed models and characterizations of ice processes for selected Middle River focus areas using either River1D or River2D18 models. The model would be selected on the basis of which model better simulates the characteristics at the particular study

location. The objective of this modeling would be to evaluate project effects on smaller scale habitat in the focus areas to provide physical data on winter habitat for Study 8.5 (fish and aquatics instream flow). The selected focus areas would be determined in conjunction with instream flow habitat and riparian studies.

5. Assess model accuracy and sources of error to evaluate the errors associated with measuring input data, estimating Manning's N under ice, and interpolating measured values over distances.
6. Assess the potential for change to ice cover on the Lower River both for fish habitat studies and an assessment of the potential effects of the project on winter transportation access and recreation. Project effects on the Lower River would be determined based on the magnitude of change seen at the downstream boundary of the River1D model, the estimated contributions of frazil ice to the Lower River from the Middle River from observations and modeling, and with simpler steady flow models (HEC-RAS with ice cover) for short sections of interest in the Lower River.
7. Review and summarize large river ice processes relevant to the Susitna River, analytical methods that have been used to assess impacts of projects on ice-covered rivers, and the known effects of existing hydropower project operations in cold climates.

FERC modified the above objectives in their study plan determination (April 1, 2013) and recommended the following:

- The Alaska Energy Authority (AEA) includes relevant international and non-hydro sites in the literature review.
- Add an additional camera at the Susitna Landing site.
- AEA conduct one additional reconnaissance flight in January to document open leads at the same time as the field data collection to document freeze up conditions.
- The analyses include an evaluation of natural conditions, as well as a range of alternatives with the dam in place. This should include reasonable operating scenarios such as maximum load-following, run-of-river, and base load, to assess project effects. Because the natural condition model would already exist, these costs would be minimal.

AEA has consistently proposed to use mathematical models to predict the projects effects on ice. The current ice process modeling effort falls short in three overarching ways:

- There are a number of ice processes that are not and cannot be simulated by the current River 1D model: the evolution of open water leads, ice characteristics and ice thickness variability in side channels, ice interactions with bed and banks, ice jam initiation during freeze-up and breakup, ice jam effects on vegetation and sedimentation in overbank areas, and the distribution of flow from main channel to side channels.
- River2D model has been selected for use in the focus areas. This is not a model that deals with ice processes. It is an adaptation of an open water flow model that allows a user to apply a layer of ice to the top of the water. It does not deal with heat flux and cannot model change in ice cover throughout the winter season.
- Very little ice thickness data has been presented so the ice part of the models cannot be calibrated or validated.

NMFS Study Modifications

NMFS recommends the FERC approved study methods be conducted as required and its study modifications incorporated as provided for in the FERC approved study plan 18 CFR 5.15(d). Support for the following requested study modification summaries is included under the applicable study objective:

2-1 Describe how ice currently interacts with the channel bed and banks and assess (using models or other methods) how that process will function under the modified winter flows (project effects).

2-2 Describe how and why open leads currently form, and how that process will function under the modified winter flows (project effects).

3-1 Describe the processes that cause ice jam initiation during three time periods (freeze up, midwinter and breakup) and, either using modeling or other methods, describe how that will change under modified winter flows (project effects) (Objectives 3 and 4).

3-2 Expand the geographic extend of the current study to include the lowest 10 miles of the Chulitna and Talkeetna and the Yentna.

3-3 Model ice processes from the bottom of the varial zone (approximately Project river mile 222) and up to the Oshetna confluence.

4-1 Assess Project effects on ice in the side channels and sloughs. Specifically ice characteristics and ice thickness.

6-1 Expand the geographic extend of the current study to include the Lower River.

7-1 NMFS recommends the literature search should be completed such that it covers the wider range of ice processes which occur in the Susitna.

G-1 (Global) Demonstrate how the River1D and River2D model will interact with three other physical processes models (8.5 Open Water Flow Model, 7.5 Groundwater Model, and 6.6 Geomorphology Model) considering that at this point they all function on different time steps.

Review by Objective

Objective 1: *Document the timing, progression, and physical processes of freeze-up and break-up during 2012–2014 in the Upper River, Middle River, and Lower River segments using the following methods: historical data, aerial reconnaissance, stationary time-lapse cameras, and physical evidence.*

AEA has more than adequately documented timing and progression of freeze-up and adequately documented breakup. Nevertheless, the physical processes documentation is difficult to evaluate.

NMFS has no modifications to Objective 1.

Objective 2: *Develop a predictive ice, hydrodynamic, and thermal model of the Middle River for existing conditions using the River1D model to simulate time- variable flow routing, heat-flux processes, seasonal water temperature variation, frazil ice development, ice transport processes, and ice-cover growth and decay. The model would be calibrated as an open-water model using known discharge events and then verified using pre-project ice data from the 1980's and data collected as part of the study for a range of climate conditions*.

The River1D and River2D models, as currently described, fail to model many important ice processes. These next three modifications identify those deficiencies and recommend changes.

Modification 2-1: NMFS recommends the objective include describing how ice currently interacts with the channel bed and banks and then, either using modeling or other methods, assess how that will change with the winter flows projected under the various operating scenarios.

The Susitna is a powerful river and large slabs of ice are primarily pushed and sometimes floated, into the side channels and sloughs. Depending on their size, they push gravels and vegetation around similar to a bulldozer blade. This process rearranges gravels, reforms banks, and keeps perennial bushes and trees from establishing on the berms at the head of sloughs. While this process is mostly documented during breakup, it happens all winter. It is not only the hydraulics of open water flows that form or maintain these macro habitats as the HEC_RAS model suggests.

The current modeling effort does not recognize the "bulldozer-like" action of a slab of ice pushing through side channels or sloughs.

This modification has some overlap with the "Model Integration New Study Request" as it does involve information from other studies including; 8.5 Instream Flow, 6.6 Geomorphology Modeling, 8.6 Riparian Vegetation and 7.6 Ice Processes. Study 7.6 should determine the magnitude of ice effects on side channel morphology today and how that would change if the project were constructed. Once that magnitude is broadly defined the model integration study would direct if or how to be integrate it into the other models.

The study was not conducted as provided for in the study plan. The model neglected this important ice process and will therefore not be an accurate predictive model.

Modification 2-2: NMFS recommends the objective describe how open leads form and how the project will change this process.

Open leads are a prevalent feature in the Susitna River. They allow for heat transfer directly from the water to the extremely cold winter air. Their presence is thought to correspond to areas of warm ground water production, very high surface velocities, or a combination of the two. The tenfold increase in midwinter discharge will not only increase velocity mid channel, but will also dilute the slightly warmer ground water.

The current study documents the presence of open leads (Visualization of Freeze-up Progression…) and suggests they are forming in similar locations to the 1980's. This information does not describe how the leads form or how the modified flow regime will alter this process.

The study was not conducted as provided for in the study plan. The model neglected this important ice process and will therefore not be an accurate predictive model.

Objective 3: *Use the River1D model to simulate conditions in the Middle River due to various project operating scenarios and predict changes in water temperature, frazil ice production, ice cover formation, elevation and extent of ice cover, and flow hydrograph. The model would also predict ice cover stability, including potential for jamming, under load-following fluctuations. For the spring melt period, the model would predict ice-cover decay, including the potential for break-up jams. Proposed operating scenarios would include, at a minimum, the load-following scenario described in the Pre-Application Document (PAD) and a base-load scenario.*

Modification 3-1: NMFS recommends that the processes that cause ice jam initiation during three time periods (freeze up, mid-winter, and breakup) be described and then, either using modeling or other methods, describe how that will change with the winter flows projected in the various operating scenarios.

Juvenile salmon overwinter predominantly in side channels and sloughs. Ice jams force water into these habitats, hold in there, and occasionally cause it to quickly drain out. This mixture of ground water and water forced into the peripheral macrohabitats by ice jams determines the environment juveniles develop in. If project operations eliminated the formation of major ice jams or caused them to form and breakup on a quicker cycle, then either scenario would greatly effect juvenile salmon development.

The current modeling effort ignores the important ice processes that happen in the four months between freeze up and breakup. The models suggest that the ice cover is a flat lake-like surface where the only real variable is the thickness of ice. The ice characteristics in side channel, slough, and tributary mouth habitats change often midwinter and the model cannot capture this.

The study was not conducted as provided for in the study plan. The model neglected this important ice process and will therefore not be an accurate predictive model.

Modification 3-2: NMFS recommends expanding the geographic extent of the current ice study to include the lowest ten miles of the Chulitna, Talkeetna and Yenta rivers.

These two confluences are not points on a map but circles of networked channels that are 2-5 miles diameter. The 2014 Study Implementation Report, Appendix A, states that it is not consistent which river freezes up first or which river breaks up first. The rate of ice production in each river can cause the initiation of lockup at Talkeetna before the ice front moving up the river reaches the confluence.

Since no ice will flow through the dam, the Upper Susitna's ice load may diminish. If the 12,000 cfs released from the dam were to keep the Susitna ice free into January, the lowest reach of the

Talkeetna and Chulitna might follow suit. When the main channels remain open, water is not backed up into the peripheral areas and the spawning gravels may dry out.

The approved study does not completely meet Objective 3 because, by ignoring the Chulitna and Talkeetna rivers, it is likely to incorrectly predict ice processes in the Middle River directly above Talkeetna. Also, the overall study goal is to predict project effects on NMFS trust resources (juvenile anadromous fish) and those fish trying to overwinter in the lowest reach of Chulitna and Talkeetna may be affected by the dam.

Modification 3-3: NMFS recommends modeling ice processes from the bottom of the varial zone (approximately Project river mile 222) and up to the Oshetna confluence. NMFS is not recommending a particular model or a particular approach.

The "varial zone" is the reach of river that is submerged when the reservoir is full, but could function like a natural river when the reservoir is mostly empty. Ideally the reservoir is mostly full in October when the ice begins to set up on the reservoir. In the next 5 months the reservoir contracts in length by several miles. This presumably leaves large slabs of ice laying on the ground and a relatively small amount of water (100-2,000 cfs) working its way down a channel partially filled with ice slabs. In 2012, when the project was initiated, we believed no juvenile fish lived in this reach. Based on 9.5 and 9.7 studies, salmon and resident fish probably over winter in this reach.

NMFS requested this same modification in our Study Plan comments (5/31/12) and verbally in several meeting since then. Our knowledge of environmental conditions has grown. Since 9.7 documented salmon in the Oshetna it is reasonable to assume they live in this reach of the Susitna, which leads to the same modification request but with a stronger justification.

Objective 4: *Develop detailed models and characterizations of ice processes for selected Middle River focus areas using either River1D or River2D18 models. The model would be selected on the basis of which model better simulates the characteristics at the particular study location. The objective of this modeling would be to evaluate project effects on smaller scale habitat in the focus areas to provide physical data on winter habitat for Study 8.5 (fish and aquatics instream flow). The selected focus areas would be determined in conjunction with instream flow habitat and riparian studies.*

This objective was not met primarily because River2D is not an ice formation or ice process model. It is a derivative of an open water flow model that allows the user to specify a thickness of ice and a roughness on the bottom side of the ice which contacts the flowing water. It does not model heat transfer, the growth or decay ice cover, ice jams formation or frazil ice production. Ice is treated as a user defined, steady state input: not a process. Additionally, River2d was applied to a single focus area rather than multiple, and the calibration and validation was done in an open water setting without ice.

Modification 4-1: NMFS recommends assessing project effects on ice in the side channels and sloughs. Specifically ice characteristics and ice thickness. Either a new model or a completely new approach needs to be used to make the assessment valuable.

Juvenile Chinook spend one full winter in side channels sloughs or tributary mouths, while coho may spend several winters. Most Susitna fish species emerge from the gravels to spend their first couple of weeks in these periphery habitats outside of the main channel. These habitats are at times: 1) open water; 2) water covered by ice of variable thickness; 3) water that is a large part frazil ice; 4) water interspersed with large overlapping slabs of ice which formed elsewhere but the river brought into the peripheral habitat; or 5) dry. The current distribution (in both time and space) of these five winter environmental conditions needs to be understood. It is highly likely that one is more conducive to juvenile development than the others. Next the study must predict whether the project will increase or diminish the availability of each condition. The study should evaluate both midwinter (January and February) when juveniles are developing, and early spring (March–April) when fry are emerging from the gravel.

The two dimensional river model (River 2D) is primarily an ice “lid” on an open water flow model. It appears like it will at best model conditions 2 and 5 and perhaps it will make the whole focus area be assigned to either open water or ice cover. Since it has not been calibrated and run, it is difficult to evaluate the River2D model.

The study was not conducted as provided for in the study plan. The River1D model is not being used in the focus areas (side channels, side sloughs, upland sloughs, and tributary mouths) and River2D only deals with determining depth and velocity underneath a user defined ice layer.

Modification 3-1, which is described under Objective 3, also applies to Objective 4.

Objective 5: *Assess model accuracy and sources of error to evaluate the errors associated with measuring input data, estimating Manning’s N under ice, and interpolating measured values over distances.*

These two models have not progressed far enough along in their development to assess accuracy. The first step in building and calibrating models is assessing their accuracy under open water conditions. In the calibration runs presented by AEA, both models performed well. While NMFS agrees that the open water flow calibration/validation is a necessary first step, the accuracy of the ice portion of the model cannot be evaluated.

NMFS does not recommend any modification to objective 5. However, we note that the model is not fully functional and therefore the objective it is not complete.

Objective 6: *Assess the potential for change to ice cover on the Lower River both for fish habitat studies and an assessment of the potential effects of the project on winter transportation access and recreation. Project effects on the Lower River would be determined based on the magnitude of change seen at the downstream boundary of the River1D model, the estimated contributions of frazil ice to the Lower River from the Middle River from observations and modeling, and with simpler steady flow models (HEC-RAS with ice cover) for short sections of interest in the Lower River.*

A prerequisite for developing the River1D model is having a calibrated and validated open water flow model. The 2.6 version of open water flow model (Hec-Ras) was not extended to the lower river, and therefore this objective could not be met.

Modification 6-1: NMFS recommends implementing Objective 6 to expand the geographic extent of the current study to include the Lower River.

Under the load following scenario the dam would release up to 12,000 cfs of 4°C water at the dam. Eighty miles below that, water would mix with less than 2000 cfs from the Talkeetna and the Chulitna. The amount and thickness of ice in the lower reach will change. Based on information from 8.5 Instream Flow Study, the stage in the lower river could vary daily by 2 feet mid-winter. This action will cause the hinge points on the edge of the suspended ice sheet to bend twice a day. Contrary to AEA's statement, the dam operator cannot set up a 300 m wide "bridged" ice sheet in December that will stay stationary for three months while the water flows underneath following the electric load. Such a bridge defies the laws of physics.

This part of the approved study plan as mentioned in the FERC study plan determination (4/1/13) was not conducted as provided for in the study plan.

Objective 7: *Review and summarize large river ice processes relevant to the Susitna River, analytical methods that have been used to assess impacts of projects on ice-covered rivers, and the known effects of existing hydropower project operations in cold climates.*

Modification 7-1: NMFS recommends the literature search be completed to covers the wider range of ice processes that occur in the Susitna.

This overview and discussion of the ice processes in the Susitna River should include:

- A discussion on ice processes that can impact fish habitat;
- Effects of hydropower projects on the river ice regime;
- Impacts of other hydropower projects and non-hydropower projects on river ice regime;
- A review of ice process modelling efforts on several hydropower projects.

The current overview provides a reasonable understanding of the main channel reaches; however, a review of processes in lateral habitats of particular interest for fish habitat is lacking (e.g., back channels and sloughs that are characteristic to the focus areas). There is limited discussion on the evolution of open water leads and the various ice types (border ice, anchor ice, and frazil ice) in the back channels and on the interaction between ice processes in the main channel and ice processes in the side channels. However, an understanding of these interactions is important to inform assumptions on the coupling of 1D ice process model results in the main channel, to the 2D modelling within the focus areas. The overview of ice process models revealed that investigators on other projects (Brayall & Hicks 2009; Hicks et al. 2009) found success predicting certain ice processes, but only at the expense of a poor prediction of water level and ice thickness. This potential limitation warrants mention since water levels and ice thickness have been identified as key parameters of interest for integration with the other modelling studies and could be a potential model limitation that may be of significant importance. The literature summarizes some past literature but was not thorough enough to cover many important ice processes.

This approved study was not conducted as provided for in approved study plans and failed to summarize several important large river ice processes.

Modification G-1: NMFS recommends that AEA demonstrate how the River1D and River2D model will interact with three other physical models (8.5 Open Water Flow Model, 7.5 Groundwater Model, and 6.6 Geomorpholgy Model) considering that at this point, all four function on different time steps.

An important aspect of the Ice modeling efforts became apparent during the March 2016 Initial Study Report meeting. The 1D ice process model will not be configured for continuous simulation over the ice- affected period. Jon Zufelt explained that the ice processes occurring over the winter simply cannot be simulated by the available models (and likely not by any available ice process model).

This study modification will be best accomplished in a new study request for model integration. NMFS has included a New Study for Model integration in a separate enclosure.

7.7 Glacier and Runoff Changes

ISR Review and Study Modifications

The Glacier and Runoff Changes (GRC) Study determination from the Federal Energy Regulatory Commission (FERC) Dispute Resolution (April 26, 2013) requires for the literature review as "described in Revised Study Plan (RSP) section 7.7.4.1." The RSP describes the literature review method: to summarize the current understanding of the rate and trend of glacier retreat and the contribution of glacial mass wasting to the overall flow of the Upper Susitna watershed, include trend analyses of glacier retreat, temperature, and precipitation." However, the implied objective, to understand potential future changes in runoff associated with glacier wastage and retreat, cannot be met through a literature review alone because no such literature exists for the region of the Susitna basin. While the Glacier and Runoff Changes Literature Review Study (7.7) provides a reasonable review of some of the ways temperature and precipitation variability may impact glaciers, the climate literature review within is brief (one page), inadequate, and does not refer to key literature relevant to Alaska. However, it does point to a range of potential temperature and precipitation changes, an unambiguous reduction in ice volume, and implications for water chemistry. A literature review is inadequate as a method to understand the future changes in glaciers and runoff with changing climate for infrastructure planning and determining project impacts from the combined and in some instances, synergetic effects of both the project construction and operations and changing climate on biota in the river.

Climate change has become a key lens through which resource management decisions must be evaluated and addressed. The existing FERC-approved Study Plan does not order evaluation of the combined effects of the Project and climate change. Given that this large project will greatly alter natural flows which wild anadromous fish are adapted to in the Susitna River, and will alter habitats that anadromous fish depend upon for various stages in their life histories, and climate change will also continue to affect these same flows and habitats, the project's effects are likely to exacerbate the effects of the project.

The existing FERC-approved Study Plan uses historical and static flows (high, low and average water years) and water temperature conditions to evaluate the proposed Susitna- Watana hydropower project's (Project) effects. The approved glacial and runoff changes study is limited to review of existing literature relevant to glacial retreat, and summarizing the understanding of potential future changes in runoff associated with glacier wastage and retreat (hereafter referred to as the Glacial and Runoff Changes (GRC) literature review, Wolken et al (2014)). This literature review approach is not adequate to assess the combined risks of climate change and

Project effects on anadromous fishes, marine mammals and their habitats, including habitats downstream of the proposed Susitna Dam on the Susitna River.

The overall goal of this study modification request is for assessment of the effects of the proposed project combined with a range of reasonably plausible risks of continued climate change on the Susitna watershed in order to condition the project license in consideration of these highly likely continued changes. Recent guidance on treatment of climate change in NMFS Endangered Species Act decisions recommends use of the RCP 8.5 emissions scenario (Representative Concentration Pathway) that takes into account current knowledge and assumes conditions similar to that new *status quo* until new information suggest that a change is appropriate (NMFS 2016). The status quo for climate emissions scenarios is not historical conditions, as proposed by FERC, but instead, is the pathway of continued increase of greenhouse gas emissions and atmospheric concentrations, air pollutant emissions, as described by projections based on RCPs.. For this project, we propose to use projections based on the more conservative RCP 6.0 as well as RCP 8.5, and also a range of plausible futures represented in at least 3 Global Climate Models. Our proposed strategy fulfills the NMFS guidelines, but will also allow testing the robustness of project operations against a range of plausible climate conditions. The proposed project is designed for long-term utility (the applicant claims at least 800 years) and is located in an area vulnerable to the effects of continued climate change. Therefore, understanding the cumulative impacts from the project and climate change is necessary to develop license conditions that protect anadromous fish, marine mammals and prey species and their temperature dependent habitats. Without this understanding, project operations would be considered in context of static future climate and hydrologic conditions when climate is known now to be in the process of changing.

In this study modification request, we identify opportunities to improve the methodology and increase the likelihood of understanding future changes in runoff and other climate-induced changes using study methodologies that are consistent with generally accepted practice in the scientific community. Therefore, the National Marine Fisheries Service (NMFS) recommends modifying and expanding the GRC literature study to:

1. Analyze changes in glacial systems and their impacts on watershed hydrology under at least three scientifically accepted climate change futures derived from state of the art global climate models (GCMs) using generally accepted downscaling methods. The Alaska Energy Authority's (AEA) modeling study (Wolken et al 2015) partially satisfies this, and NMFS recommends that study, as modified herein, be ordered by FERC.

2. Assess the impacts of the Project on climate-influenced resources including anadromous fish and their habitats and habitat components, under a range of future climate projections

(at least three) that are accepted by the climate science community. Because there is a range of scientifically supported future climates projected using the state of the art GCMs, and because this range of climate projections will likely have different impacts on NMFS trust resources, it is necessary to assess risks at the lower-end, middle, and higher-end of that range (e.g, see Wolbus et al 2015 and Leppi et al 2014).

3. Provide NMFS with adequate information necessary to assess the combined impacts of the Project and climate change on its trust resources including data and a modeling framework for analysis of options to condition the license.

Furthermore, NMFS proposes this study modification pursuant to the regulations authorizing study modifications found at 18 C.F.R. § 5.15 (e). NMFS submits that the record supports the conclusion that NMFS has shown good cause for the issuance of this study modification and, as explained further below, that all regulatory requirements are addressed. In particular, NMFS submits that FERC will find that significant new information, material to the study objectives has become available, in the form of a new generation of climate models and downscaled output made available since NMFS' initial study requests were submitted in May, 2012: the latest results from GCMs developed and run as part of the Coupled Model Intercomparison Program, Phase 5 (CMIP5) which were used in support of the 2013 IPCC Fifth Assessment Report (IPCC 2013) and form the basis for numerous climate impact studies; new downscaled climate projections; and new analysis of climate change effects on Susitna's glaciers and the runoff downstream; and significant new use of climate change information in planning water infrastructure projects in high latitudes, throughout the nation, in Alaska, and, throughout the world; and new scientific assessments of the effects of changing climate on biotic resources that would also be affected by the Project. The application of these new data and models has become the generally accepted practice by water infrastructure and natural resources managers. This new information has developed since NMFS initial requests were submitted in 2012. As FERC noted in its July 18, 2014 Order Rejecting and Denying NMFS and the Center for Water Advocacy's requests for rehearing of the formal study dispute determination, "as climate change modeling continues to advance, it may eventually yield data and knowledge that can and should be used to formulate license requirements that respond to environmental effects caused by climate change." (NMFS directs FERC, by reference, to the study dispute record which holds additional relevant information supporting the study modification request.) NMFS presents the new advancements in climate change modeling here, which have become standards in the management of natural resources affected by the combined effects of changing climate and water management, and we request the applicant use this study methodology that is consistent with generally accepted practice in the scientific community.

Specifically, state-of-the-art CMIP5 climate model projections have now become publically available as both dynamically downscaled (e.g. Zhang et al 2015) and statistically downscaled (SNAP 2016) climate projections for Alaska. An effort to dynamically downscale projections from additional GCMs that would sample a larger range of projected changes is in progress at the University of Alaska (U. Bhatt, pers. comm.). These downscaled products are available for use as improved methods for considering the range of (or uncertainty among) plausible projected futures among GCMs, in planning for water infrastructure and assessing the combined effects of water management and changing climate on water and temperature dependent natural resources (Shanley and Albert 2014; Leppi et al 2014; Wobus et al 2015). Methods for incorporating climate projections into management analysis are described below in sections 4 (existing info and need for additional) and 6 (consistency with generally accepted practice). We are now making FERC aware that new climate change study techniques are available which are useful and can be applied in a FERC ILP to improve past procedures, which are now no longer generally accepted practices in the scientific community.

Furthermore, a modeling study of the upper Susitna basin funded by the AEA (Wolken et al 2015) finds that as a result of projected temperature increases glaciers will retreat, a greater proportion of precipitation will fall as rain, evapotranspiration will increase, and permafrost will thaw, resulting in changes in the timing and magnitude of runoff, an increase in glacial runoff while glaciers are melting rapidly, followed by a general reduction in the contribution of glacial runoff to flow in the Susitna as the glacier-covered area becomes smaller. The findings include climate change information that could change the outcome or conclusions drawn from many other FERC-ordered pre-licensing studies of anadromous fish, marine mammals, their prey and their habitats, including hydrology upstream and downstream of the Susitna Dam and in important lateral side-channel habitats of the river. Despite the fact that the applicant had elected to fund and conduct the study, and FERC's statement that FERC would use information from this study in its licensing decision, FERC dismissed discussion of that part of the study in the ILP hearing. Climate changes are not unforeseen, and are likely to continue over the term of any new license for the Project, and interact with Project operations and facilities to exert additive and possibly synergistic effects on anadromous fishes and their habitats and many other biotic resources in the Project area that are also affected by the Project. These predictable continued changes will not be effectively studied and evaluated through the use of conventional hydrologic studies, monitoring techniques, and predictive models.

Finally, the Alaska chapter of the National Climate Assessment presents new analysis of trends in temperature, precipitation and glacier melt (Stewart et al 2013, Markon et al 2012). Consistent with these reported trends, Southcentral Alaska has experienced record temperatures from 2013 to 2016 according to the NOAA's National Weather Service, Alaska Region. This information indicates that climate change is currently affecting the Project area and will continue to do so over the 50-year term of any new license issued for the Project and for the life of the project (AEA estimates the project life to be about 800 years).

Taken together, this information is necessary for NMFS to use in developing measures which would, if implemented, protect, mitigate or enhance fish and wildlife resources affected by the licensing and construction of such a large, water, snow and ice dependent project and be used in making our decision to prescribe fishways under Section 18 of the Federal Power Act. NMFS provides further explanation of good cause below, as required under the regulations.

We recommend the following study elements and methods, which are generally accepted practice in water infrastructure planning (as documented below in section 6):

1. Update and expand the GRC literature review (previously ordered by FERC) to include new published studies and new information available and a more comprehensive scope of studies in the literature.

2. Acquire and evaluate downscaled climate projections for the Susitna Basin that sample a range of projected climate change for use in further glacial and hydrologic impacts modeling, including Zhang et al (2015) downscaling which was used in the AEA modeling study (Wolken et al 2015).

3. Acquire and evaluate existing downscaled glacier and runoff projections for the Susitna basin that sample a range of future conditions and that allow the evaluation of the Project under a range of future climate-driven risks. The AEA modeling study (Wolken et al 2015) would partially satisfy this element.

4. Acquire or develop projections for streamflow, water temperature and quality in the reservoir and below the proposed dam for use in assessing impacts of the Project on species of interest under future climates.

5. Summarize potential effects of the Project under a range of climate projections in a Climate Change Technical Report.

6. Coordinate study data and results with other technical working groups conducting FERC-ordered pre-licensing studies that the project may exert additive and synergistic effects upon, e.g., of anadromous fishes, marine mammals, their prey and their habitats, including hydrology upstream and downstream of the Susitna Dam and in important lateral side-channel habitats of the river, as well as the Model Integration and Decision Support Study NMFS is also requesting. These studies include: 5.5 Baseline Water

Quality, 5.6 Water Quality Modeling, 5.7 Mercury Assessment and Potential for Bioaccumulation, 6.5 Geomorphology, 6.6 Fluvial Geomorphology, 7.5 Groundwater, 7.6 Ice Processes Study, 7.7 Glacier and Hydrology Changes, 8.5Instream Flow and Habitat Suitability Criteria, 8.6 Riparian Instream Flow, 9.5 Fish Distribution and Abundance in the Upper Susitna River, 9.6 Fish Distribution and Abundance in the Middle and Lower River, 9.7 Salmon Escapement, 9.8 River Productivity, 9.11 Fish Passage Feasibility at the Susitna-Watana Dam, 9.12 Fish Passage Barriers in the Middle and Upper Susitna River and Susitna Tributary, and 9.17 Cook Inlet Beluga Whale.

FERC has previously denied nearly all study requests pertaining to climate change, including most of NMFS's initial request for the proposed Susitna dam and hydropower project stating that the science is speculative in nature and based on methodology not yet proven to reliably quantify climate change effects or be useful for licensing decisions and developing license terms and conditions. FERC's analysis of climate models and its rationale for these decisions has not been published or made public for review by NMFS, peer-review by the climate science community, or other licensing participants, including the applicant. NMFS does not need to know with precision the magnitude of change over the relevant time period if the best available information allows NMFS to reasonably project the directionality of climate change and overall extent of effects to species and their habitats. NMFS urges the FERC to reevaluate the approach to their assessment of this and other climate change requests, using the methods outlined in the Study Modification Request below and, importantly, to make the basis of FERC's decisions public and transparent.

Based on this new information, NMFS requests that FERC in its Updated Study Determination revise the Study Plan and order both AEA's study of projected climate changes on the Susitna basin (Wolken et al 2015), and our request for the study of the cumulative effects of continued climate change on the environmental baseline and Project related effects over the proposed license term and the reasonable life of the project. This information is necessary to adequately study the effects the project in combination with continued climate change on anadromous fishes, marine mammals, prey species and their habitats, for the Susitna-Watana Project (Project), which will have effects of the river both upstream of the dam and reservoir and downstream. Although cost considerations aren't included in a study modification under FERCs ILP regulations, we are providing cost estimates because cost was a concern of FERCs in the original request.

NMFS requests that FERC carefully consider how, absent information from evaluation of the Project's effects in the light of existing and future climate change, the draft license application will be able to meet the requirements for content. NMFS requests that the Director fully explain how this situation will be resolved when issuing a decision regarding a new or amended Study Plan for the Project.

Background

The implied objective of the proposed modifications to the GRC study is to understand potential future changes in runoff associated with glacier wastage and retreat, which are required by NMFS to adequately analyze the effects of natural variability and changing climate conditions on NMFS' trust resources. In order to do so, NMFS must obtain and apply the best available science, and use current data and techniques to assess the potential effects of the Project on riverine processes, fish, and fish habitat. NMFS needs to understand the likely effects of changing climate on hydrology, anadromous fishes, marine mammals, prey species and their habitats in order to develop license terms and conditions that are optimally protective of fish and their habitats, and also comply with legal requirements under the Essential Fish Habitat Provisions of the Magnuson-Stevens Fishery Conservation and Management Act, the National Environmental Policy Act (NEPA), Endangered Species Act (ESA), Clean Water Act, and the Fish and Wildlife Coordination Act. NMFS is requesting information or study of the effects of the Project and its operations. Climate change is and will continue to affect the environment of the Project in a variety of ways that will have implications for the operational viability of the project and will provide fundamental information necessary by NMFS and all other stakeholders including FERC in making licensing decisions and developing recommended license terms and conditions - PM&Es (protection, mitigation, and enhancement and mitigation measures), 10(a)s, 10(j)s, and Section 18 fishway prescriptions. Combined project operations along with climate change effects are likely to have the following effects:

- Changes in streamflow volume and timing, and changes in stream temperature: Decreased snowpack and glacial runoff combined with increased air temperatures will change the thermal regime of the Susitna River. Water Temperature *below* the proposed dam will be affected by climate change *and* by the dam and reservoir and how it is operated. This will affect fish and their habitat and may have implications on operations needed to meet license conditions.

- In the freshwater environment, hydrologic variability and the salmon life cycle are closely linked, so that climate-induced, and project exacerbated changes in hydrologic regimes are likely to influence salmon productivity. Increased stream temperature and decreased summer flows could cause harmful or even lethal effects to fish and aquatic invertebrates (Wobus et al 2015; Leppi et al 2014; Kyle and Brabets 2001). Flows are likely to change during much of the year - increased spring and late summer flows are likely to occur because melting of the snowpack occurs earlier due to warming and glacier melting increases -until such time as receding of glaciers results in reduced summer flows. Stream temperatures are likely to continue increasing in the future, which could shorten salmon egg incubation times and increase juvenile growth rates (Piper et al 1982), as well as reduce thermal habitat suitability and survival (Richter and Kolmes 2005; Munoz et al 2014). Since climate changes at high latitudes are amplified relative to other parts of the world, all of these potential changes could be more dramatic and more rapid in Alaska than at lower latitudes (Serreze and Barry 2011).

- Sedimentation could impact project longevity and thus cost-benefit calculations. Sedimentation gradually reduces the capacity of reservoirs, as well as causing abrasion on the turbines and other dam components. The rate of sedimentation is strongly tied to climate and erosion processes. As the climate warms, changes in events such as the magnitude and timing of spring flooding due to ice breakup, and vegetation changes, may have a large impact on sediment transport into reservoirs and into reaches far downstream of the project.

- Sedimentation rate changes below glaciers above the reservoir and in downstream tributaries will affect project longevity and fish habitat.

- Changes in vegetation type and amount driven by climate change could lead to changes in the hydrologic regime and in riverine habitat quality.

Based on the best scientific information available, the proposed project will be operating in an environment with a changed climate which is novel compared to the previous variable climate. Climate projections can be used to assess the range of plausible risks and effects of climate change, and then we will be able to assess the combined effects of climate and the reservoir on the resources to develop license terms and conditions that are optimal under current and future conditions of changing climate.

While neither FERC nor the applicant can control climate change, they can mitigate how much the project would additionally stress the resource in addition to climate change, or alternately, the project could mitigate some effects on the resource, for example, by regulating downstream temperatures or improving access to higher elevation habitats. Temperature and precipitation data from GCMs that is downscaled to relevant scales should used to provide a range of future scenarios for the Susitna River basin. The results will be useful to inform analyses of Project operations and potential instream flow requirements and other license conditions. The uncertainty associated with the scenario analysis and downscaled temperature and precipitation projections should be considered in long-term planning and assessment by using scenario based risk assessment. Additionally, an understanding of changes in the hydrologic regime (water timing, quantity, and quality) in combination with project operations should inform post project monitoring needs. This must include stream temperature measurements, assessment of fish habitat conditions under changing conditions, instream flow throughout the system to assess changes in flow contribution from tributaries, and stream temperature monitoring in the reservoir and downstream.

NMFS must, in requesting a study, demonstrate that the proposed study methodology "is consistent with generally accepted practice in the scientific community" (18 CFR § 5.11(d)(5)). The current "generally accepted" practices for water management recommend moving beyond the concept of a stationary climate and hydrology (Milly 2005) to consider a range of possible future climate and hydrologic scenarios, as we will describe below, including those that are consistently represented in the GCM projections and data spatially downscaled from the GCMs to regional and local scales, such as the Susitna basin. Downscaled temperature and precipitation data are now routinely analyzed to assess future risks, and can provide a range of future likely scenarios for the Susitna River basin hydrologic regime considering all inputs, including precipitation, temperature, soil moisture, evaporation and transpiration and a range of plausible futures of these variables. The state of the art of GCMs and the existing information about climate risks for the Central Alaska Range and Talkeetna Range region are described below in section 4.

Numerous studies have developed methods to incorporate this uncertain information into long-term planning processes. The examples range from scenario-based sensitivity studies to complex regional modeling (see Brekke et al 2009a for examples).

Thus, the use of a range of plausible climate futures in a risk assessment framework have become the generally accepted practice in the scientific and water management communities as strategies for using climate projections; this study request will describe the current practices for the use of climate projections in a risk management framework, in use and mandated by other non-federal and federal and water management, resource and infrastructure planning processes. These climate risk assessment strategies include scenario planning and robust decision making.

Applying these recent advances in climate science and the use of climate science in long-range planning to the project analysis will result in more informed resource decision making (Reclamation 2016; Viers 2011; Vicuna et al 2010; Brekke 2009a,b; Fowler 2007) that reflects a range of plausible risks to the project. FERC has expressed concerns about the utility, accuracy and uncertainty of climate projections, as in its 2009 rejection of a climate change study request in relicensing the Yuba-Bear Drum-Spaulding (P-2266) hydroelectric facilities. Recent advances in the application of climate science address FERC's concerns, by developing risk assessment strategies for considering a range of plausible futures in a risk assessment framework (e.g., Groves et al 2013, Reclamation 2016, 2011). However, the concept of a stationary environmental baseline with fluctuations (high and low water years) around a relatively stationary mean (as previously used by FERC and other regulators) is an outdated concept given the current level of scientific certainty of climate change (Milly et al 2008; Viers 2011). The recent scientific advances are now part of generally accepted practice, as described below in section 6.

The requested modification to the glacier and runoff study will allow FERC to incorporate the projected risks of climate change in the current climate science into comprehensive decision making, and provide information NMFS can use to develop: proposed measures and plans to protect, mitigate, or enhance environmental resources; Federal Power Act (FPA) section 18 fishway prescriptions for passage of anadromous fish; FPA section 100) recommendations to protect, mitigate damages to, and enhance fish and wildlife resources; and develop FPA section 10(a) recommendations to ensure that the project is best adapted to comprehensive plans for developmental and non-developmental resources. These provisions, in turn, will enable FERC to base its licensing decision on substantial supporting evidence. A simple literature review is insufficient to adequately incorporate the projected risks of climate change into these license conditions.

Furthermore, the Cook Inlet distinct population segment of beluga whales is an ESA-protected species that could be the subject of ESA consultation regarding the Project licensing are also the subject of this request; all 5 salmon species in the Susitna are important prey species for the beluga whale. Projects constructed according to designs that do not anticipate future climate conditions may fail to meet ESA objectives under different conditions, causing adverse effects to listed species.

The overall goal of this study modification request is to assess the effects of the proposed project combined with a range of plausible risks of climate change on the Susitna watershed in order to condition the project license in anticipation of these changes. The proposed project is designed for long-term utility and is located in an area vulnerable to the effects of continued climate change. Therefore, understanding the cumulative impacts from the project and climate change is necessary to develop license conditions that protect anadromous fish, marine mammals, prey species and their habitats. Without this understanding, project operations would be considered in context of static future climate and hydrologic conditions, when it is clear that “baseline” conditions are not likely to be stationary (Wobus et al 2015).

NMFS requests that the climate study be based on fundamental methodologies in the peer-reviewed literature (e.g., downscaling in Zhang et al 2015, and use of multiple futures in Leppi et al 2014 and Wobus et al 2015). Although the specific application may not yet be peer-reviewed, e.g. Wolken et al (2015); it would be reasonable to include new analyses derived from existing data sets or model projections that are in the peer-reviewed literature. The methodologies set forth herein are consistent with and well-anchored in generally accepted scientific practices, and are currently being used to inform other agency and long-term water management actions, as described in this section.

NMFS recommends modifying and expanding the GRC literature study objective to include the following objectives:

1. Analyze changes in glacial systems and their impacts on watershed hydrology under at least three scientifically accepted climate change futures derived from state of the art GCMs using generally accepted downscaling methods.The AEA modeling study (Wolken et al 2015) partially satisfies this recommendation.

2. Assess the impact of the Project under a range of future climate projections (at least three) accepted by the climate science community.

3. Provide NMFS with the information adequate to assess the combined impacts of the Project and climate change on its trust resources including data and a modeling framework for analysis of options to condition the license.

NMFS Study Modifications

In order to accomplish these objectives, NMFS recommends the following modified and additional study elements be conducted for the project:

1. Update and expand the GRC literature review (previously ordered by FERC) to include new published studies and information available and a more comprehensive scope of studies in the literature.

2. Acquire and evaluate downscaled climate projections for the Susitna Basin that sample a range of projected climate change for use in further glacial and hydrologic impacts modeling, including Zhang et al (2015) downscaling which was used in the AEA modeling study (Wolken et al2015).

3. Acquire and evaluate existing downscaled glacier and runoff projections for the Susitna basin that sample a range of future conditions and that allow the evaluation of the Project under a range of future climate-driven risks. This includes the AEA modeling study (Wolken et al 2015) based on the Zhang et al (2015) downscaling.

4. Acquire or develop projections for streamflow, water temperature and quality below the proposed dam for use in assessing impacts of the Project on species of interest under future climates.

5. Summarize potential effects of the Project under a range of climate projections in a Climate Change Technical Report.

6. Coordinate and update study data and results with other studies including the Model Integration and Decision Support Study NMFS is also requesting, and technical working groups conducting other FERC-ordered pre-licensing studies that the project is likely exert additive and synergistic effects upon.

Review of Proposed Study Modifications

Study Modification 1: Update and expand the GRC literature review (previously ordered by FERC) to include new published studies and information available and a more comprehensive scope of studies in the literature to include the following:

a. New literature published since 2012.

b. A review of existing literature on climate change impacts on ecosystems in this region, and in particular any literature relating to the effects of climate change on species identified below in reference to **18 CFR § 5.9 (a)**. A wider scope including possible effects of changing climate on water temperature and forest/vegetation change and other aspects

c. A concise summary of the findings in the literature review of likely impacts of changing climate and plausible ranges on the Susitna Basin based on the literature.

Study Modification 2: Acquire and evaluate at least three downscaled climate projections for the Susitna Basin that sample a range of projected climate change for use in further glacial and hydrologic impacts modeling. This effort will include:

a. Obtain downscaled climate model projections sufficient for the follow-on hydrologic modeling in Elements 3 and 4 below from at least three models, including the Zhang et al (2015) downscaled projection that was used in the AEA modeling study (Wolken et al 2015). The projections should include a range of warming and precipitation change, including futures with high and low precipitation changes, as well as smaller and greater warming. An example of the range of temperature and precipitation changes from CMIP5 climate models for the Susitna region is shown if Figures 3 and 4. Work currently in progress at the University of Alaska Fairbanks and the Alaska Climate Science Center to apply the Zhang et al (2015) Weather Research and Forecast (WRF) model dynamical downscaling to additional GCMs (U. Bhatt, personal communication, 24 May 2016) would likely meet this requirement. Other possible sources include model output from the following international coordinated downscaling projects CORDEX-North America; NARCCAP (Mearns et. al 2003); CORDEX-Arctic. Although the NARCCAP and CORDEX products do not all cover all of the state of Alaska, some of the downscaled GCMs sufficiently cover the region around the Susitna to be reasonable to use for analysis. These downscaled data would need to be subjected to the same bias correction procedure as noted in Wolken et al (2015).

b. Evaluate these projections and the GCMs they were derived from in terms of their positions in the array of possible futures indicated by CMIP5 climate models.

c. Electronically publish model output for the Susitna Basin and make available to NMFS researchers and others for further studies; Leppi et al (2014) used a similar strategy of multiple strategically-chosen GCMs to drive hydrologic and Coho Salmon models to assess changes in fish production in the Chuitna River and Wobus et al (2015) used a similar process to assess the combined risks of climate change and mining on Pacific salmon and habitats in the Bristol Bay watershed of southwestern Alaska.

Study Modification 3: Acquire and evaluate existing downscaled glacier and runoff projections for the Susitna basin that adequately sample a range of future conditions and that allow the evaluation of the Project under a range of future climate-driven risks. This includes the AEA Glacier and Runoff Study based on the Zhang et al (2015) downscaling. Wolken et al (2015) implement and calibrate a hydrologic model for the Upper Susitna Basin that includes a model of glacial change. We believe that this model is adequate for the current study.

a. Include the results from the full Wolken et al (2015) Glacier and Runoff Changes study, including the modeling component and future projections.

b. Use the Wolken et al (2015) modeling framework to investigate at a minimum two additional climate projections (described in Element 2). Alternatively, another glacier and hydrologic modeling framework may be used provided it is run for an adequate sample of future climate inputs.

c. Electronically publish model output and make available to NMFS researchers and others for further studies.

Study Modification 4: Acquire or develop projections for streamflow, water temperature and quality below the proposed dam for use in assessing impacts of the Project on species affected by the project *and* climate change, and their habitats, under future climates.

a. Provide simulation of water temperature, streamflow amount and timing below the proposed dam downstream to the downstream extent of project effects for the scenarios described above for future periods extending from the near future to 2100.

b. This data is needed by NMFS in order to establish the altered environmental baseline trends against which the effects of the Project on anadromous fish and associated habitat will be assessed for the license term and the reasonable life of the project.

Study Modification 5: Summarize potential climate change effects under a range of climate projections in a Climate Change Technical Report.

This technical report should include a description of the assumptions made, models used, and other background information. The report will provide interpretation and guidance on the science knowledge developed, in order to translate them into useable knowledge, through syntheses and translational products developed to address the hydropower, water, and fisheries needs. Additionally this report will include an analysis of the impacts of projections on the project nexus, and hydropower facilities. The report will include an electronic supplement that makes the data used in this study available for the use of other studies.

Study Modification 6: Coordinate study data and results with other studies and technical working groups.

Existing Information and Need for Additional Information: This section is provided in view of the development of significant new information since the original request. The previous standard of a stationary environmental baseline with fluctuations (high and low water years) around a relatively stationary mean is now considered an outdated concept given the current level of scientific certainty of climate change in the citations described below, and in studies done previously (Milly et al 2008; Viers 2011).

<u>Observed Changes in Temperature and Precipitation</u>

More comprehensive and up-to-date summaries of observed climate changes in Alaska have become available. A summary assessment of the science in the National Climate Assessment (NCA), Alaska Chapter (Chapin et al, 2014) states that "[…climate change impacts in Alaska are already pronounced, including earlier spring snowmelt, reduced sea ice, widespread glacier retreat, warmer permafrost, drier landscapes, and more extensive insect outbreaks and wildfire." All these climate change trends could have significant impact on anadromous fish habitat and on the operations of the proposed Project in the Susitna River basin, largely through their impacts on water quantity, timing, and quality in the basin.

Regional temperature analyses show that Southcentral Alaska has warmed in the past few decades. At the Talkeetna weather station, average winter temperatures increased from 1949-2011 by almost 9 °F, and annual average temperatures increased almost 5 °F (Figure 1a; also see Stewart et al 2013, Table 1). Southcentral Alaska experienced record warm conditions in the past two winters with the average winter temperature 5-6 °C (8-10 °F) above the long-term average. The temperature record from Gulkana, AK (Figure 1b) which is indicative of the Southeast Interior region, has also shown increasing temperatures. These trends are also consistent with what was reported in the recent National Climate Assessment (NCA), Alaska Chapter (Chapin et al, 2014) states that "[o]ver the past 60 years, Alaska has warmed more than twice as rapidly as the rest of the United States, with statewide temperatures increasing by 3 °F and average winter temperature by 6 °F, with substantial year-to-year and regional variability."

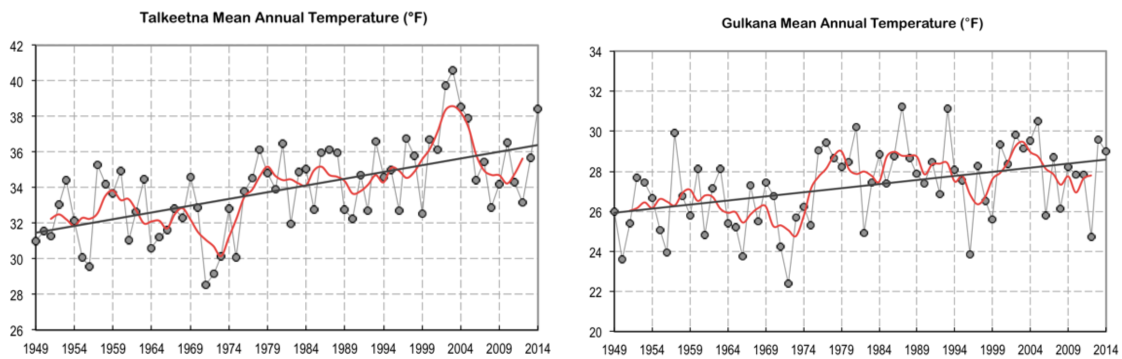

Figure 1. Mean annual temperature, 1949-2014 at Talkeetna (left), and Gulkana (right) from the Alaska Climate Center http://akclimate.org/ClimTrends/Location (downloaded June 13, 2016).

Analysis of weather stations in southcentral Alaska including Talkeetna found an increase in the occurrence warm extremes (the warmest 1% of daily high temperatures of the baseline period), as well as a decrease in the frequency of cold extremes (coldest 1% of daily lows of the baseline period) at all stations in the region. These temperature trends are consistent with those shown in Figure 2, reproduced from Bieniek et al (2014), who performed a regional analysis based on objectively chosen climate divisions for Alaska. While they find large variability on multi-decadal time scales associated with the Pacific Decadal Oscillation (PDO), they also found "... a gradual upward trend of Alaskan temperatures relative to the PDO since 1920, resulting in a statewide average warming of about 1°C." The conclusion that the there is likely a warming trend is also supported by the NCA (Chapin et al, 2015) who note that "the warming trend has moderated the effects of the more recent shift of the PDO to its cooler phase in the early 2000's."

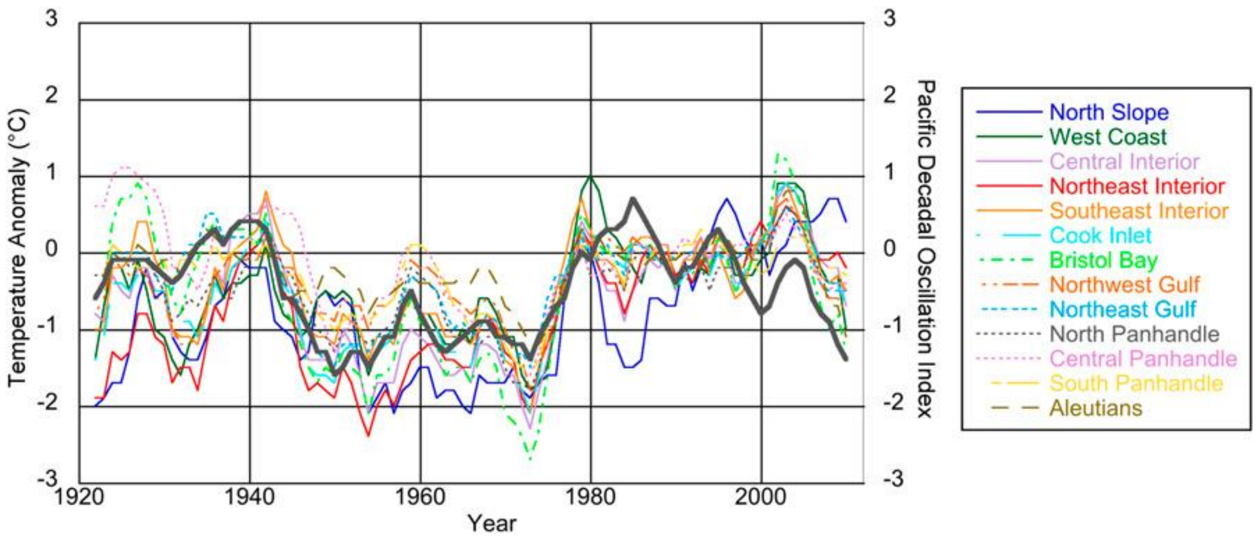

Figure 2. Annual 5-yr running averaged divisional temperature anomalies for the 13 Alaska climate divisions. The Pacific decadal oscillation index (PDO) (http://jisao.washington.edu/pdo/) is shown in dark gray and has also been smoothed by 5-yr running average. The mean of the PDO has been adjusted to match the average mean of the 13 climate divisions for ease of comparison. Low-frequency variations of annual divisional temperature anomalies appear to follow that of the PDO. (Reproduced from Bieniek et al, 2014)

Trends in precipitation are more regionally variable. Stewart et al (2014), analyzing 26 stations from across Alaska, an increase of about 10% in precipitation statewide from 1949-2005; precipitation extremes, defined as the heaviest 1% of three day precipitation totals, have increased in the south central area by 60% in the fall, and 40% for the other seasons (Stewart et al 2013). However, Bieniek et al (2014) found large temporal and spatial variability in precipitation trends. Uncertainty in the recent precipitation trends along with uncertainty in precipitation projections (see below) motivates the need to study a range of climate projections to properly characterize risk.

Most glaciers in Alaska and British Columbia are shrinking substantially. This trend is expected to continue and has implications for hydropower production, ocean circulation patterns, fisheries, and global sea level rise," (Chapin et al 2014). One recent study analyzed the Susitna River at Gold Camp from 1949-2013 and demonstrated that "annually, maximum flow values are declining, particularly in the glacial-nival systems (Susitna and Talkeetna) and in the mid-elevation sites that are snow melt dominated (i.e. Chena)" while also reporting increases in annual minimum flows (Bennet et al 2015).

Environmental Baseline

Climate and hydrologic data are part of long-term natural resource assessments collected in the watershed since the late 1970s (and some habitat assessments dating to the 1940s). These assessments document trends toward earlier snow melt, warming air temperatures, shifts in precipitation, increases in stream temperatures, declines in fish populations, increases in the length of the growing season as temperatures increase. Other changes noted in the region include a decrease in boreal forest growth. Increases in temperature and changes in precipitation have had profound effects on regional hydrology, including shrinking wetlands, glacial recession (and in some less frequent instances, glacial surging), permafrost melting, and an increase in fire frequency and intensity across the landscape as a result of increased drought and thunderstorms (SNAP 2011). Given the trends (as shown in Figures 1 and 2 above), there is need to document the environmental baseline of the project, and develop a realistic projection of the range of potential trends in the future, in order to evaluate the potential project effects and to fashion license conditions.

Projections of the Future

Climate models project increased temperature and precipitation in South Central Alaska. Figure 3 shows projected annual temperature and precipitation change between time periods at the end of the 20th and 21st centuries for a region encompassing the Susitna River Basin for Representative Concentration Pathway 6.0 (RCP6.0), a middle scenario of future greenhouse gas concentrations. The specific climate model and emissions scenario that were downscaled by Zhang et al (2015) and used in the AEA modeling study is indicated, and lies in the middle of the range of changes expressed by the full array of CMIP5 models. Figure 4 shows the temperature and precipitation changes for the RCP 8.5 concentration pathway, which assumes larger greenhouse gas emissions, including the five climate models that the Scenario Network for Alaska and Arctic Planning (SNAP) evaluated as their preferred models for use. These "SNAP-preferred" models span the bulk of the range, with the exception of two outlier models; the range of these "SNAP-preferred" models would be adequate to represent a high, medium, and low change future climates. Additional information on the models, including abbreviations used, model components, and evaluation of performance can be found in Chapter 9 of the IPCC 5th Assessment Report (Flato et al 2013).

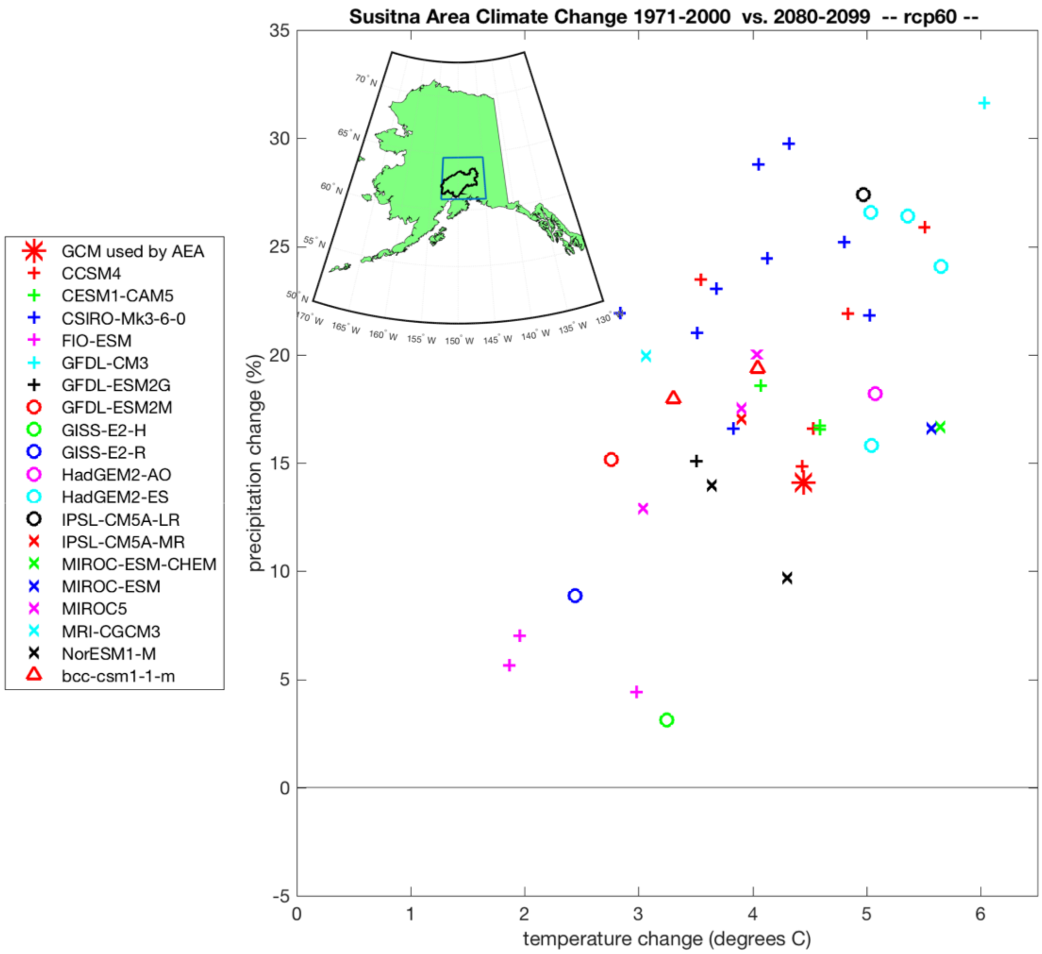

Figure 3. Range of temperature and precipitation changes in South Central Alaska from CMIP5 Climate models using RCP 6.0, a middle emissions scenario of climate change. Climate model names follow CMIP5 conventions, with multiple runs from individual models shown were available. The scatter among models is due to uncertainty in the scientific representation of climate processes. The scatter for individual runs of the same model is due to simulated multi-decadal variability. The area over which precipitation and temperature changes are averaged is

shown in the inset map, along with the Susitna River basin. The specific model used in the AEA Glacier and Runoff modeling study (CCSM4 Run6) is denoted by a red asterisk.

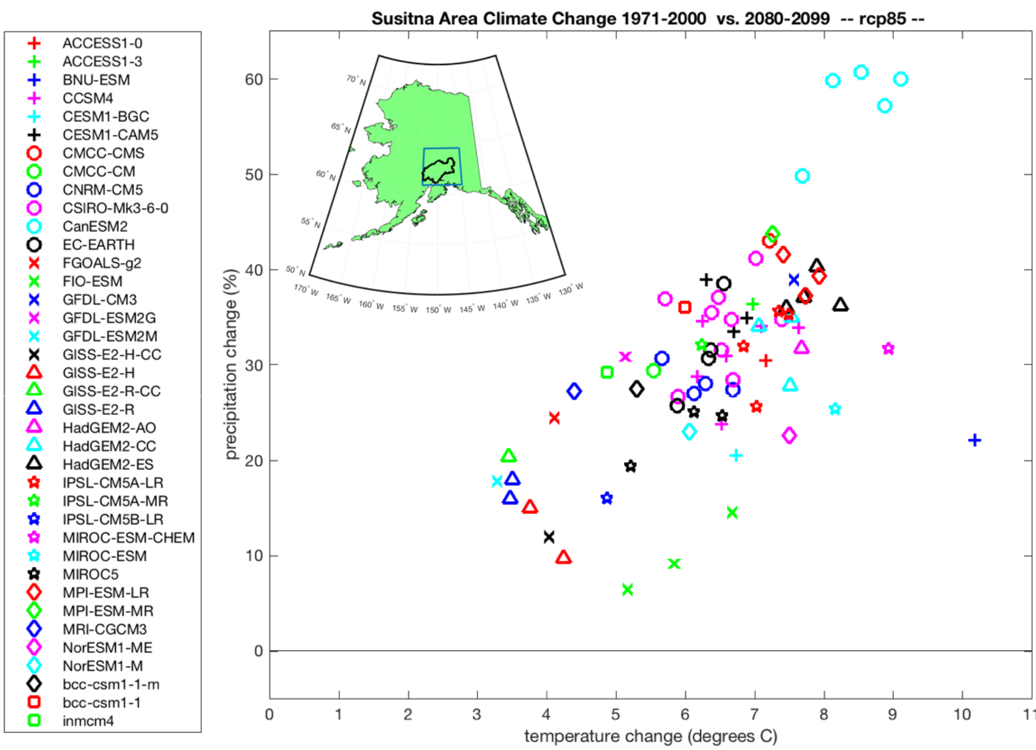

Figure 4. As in Figure 1, except for RCP 8.5, a high-end emissions scenario of climate change. Projections from a larger number of climate models are available for RCP 8.5 than for RCP 6.0. Note that the following models were selected by the Alaska Scenario Network (SNAP) as preferred for Alaska based on evaluation of their historic climate simulations: NCAR-CCSM4, GFDL-CM3, GISS-E2-R, IPSL-CM5A-LR, MRI-CGCM3, and that these models effectively span the range shown here with the exception of the CanESM2 (light blue circles) and BNU-ESM (dark blue cross) models.

A warming climate has a profound impact on mountain glaciers, as is shown in (Chapin et al 2013; Stewart et al 2013; Wolken 2014; and cites within these). The modeling study funded by the AEA (Wolken et al, 2015) finds that as a result of projected temperature increases glaciers in the Susitna River basin will retreat, a greater proportion of precipitation will fall as rain, evapotranspiration will increase, and permafrost will thaw, resulting in changes in the timing and magnitude of runoff, an increase in glacial runoff while glaciers are melting rapidly, followed by a general reduction in the contribution of glacial runoff to flow in the Susitna as glacier covered area becomes small. Figure 5 shows the peak glacial-fed contribution to flows at Denali declining from near 100% to 50-60% of flow. Figure 6 shows continued strong and variable glacial runoff until mid-century, followed by strong declines in glacial runoff.

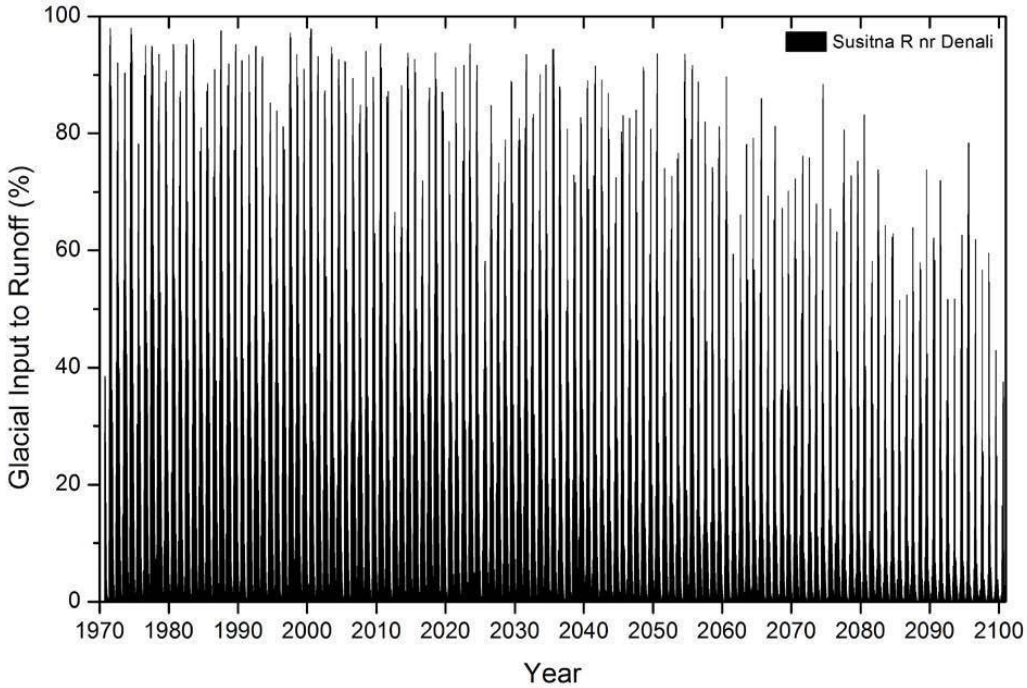

Figure 5. The percentage of glacial input to simulated total runoff at the Susitna River near Denali station for the period 1971-2100. (Reproduced from Wolken et al 2015, Figure 7.4.2.1-17)

While glacial runoff is very sensitive to temperature change, total runoff and annual streamflow in the basin is sensitive to the annual precipitation as well, for which there is significant uncertainty. The significant declines in annual maximum flow in the historic record as reported by Bennett et al (2015) are a complex response to natural variability and long-term trends in both temperature and precipitation. The proposed study modifications would address the future hydrologic conditions under a range of climate projections consistent with the current state of scientific knowledge.

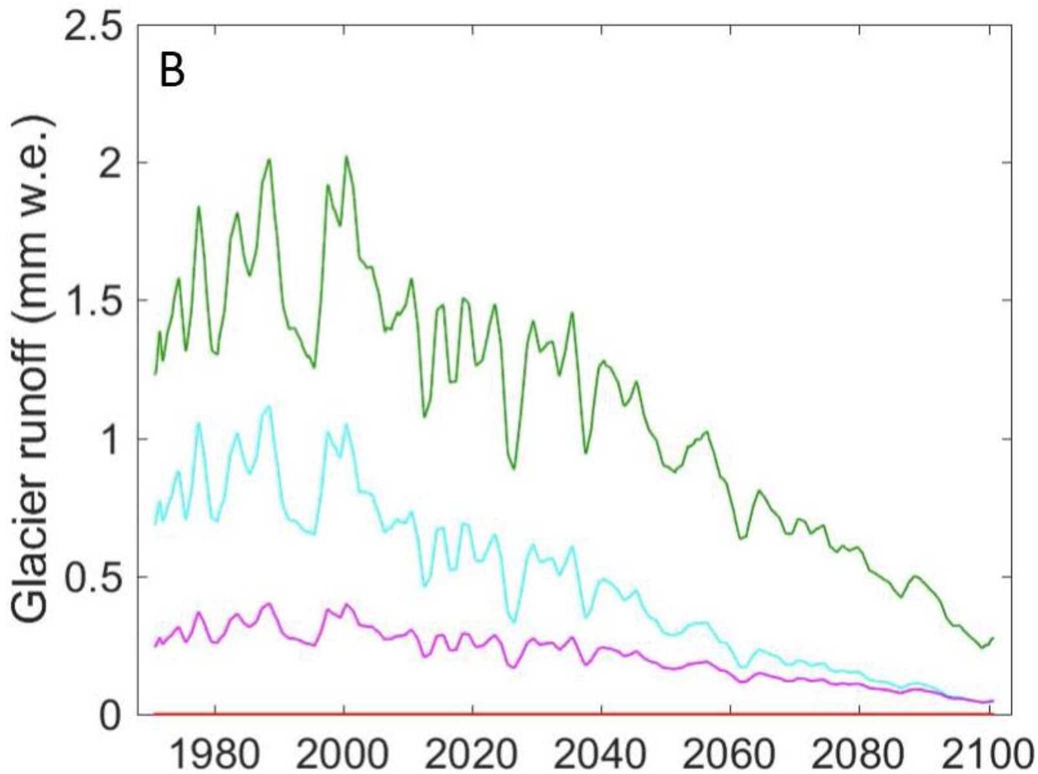

Figure 6: Simulated daily runoff (mm w.e.) from glaciers for sub-basins in the upper Susitna basin for the period 1970-2100. Note that the entire glacier area is classified into either 'firn area' or 'ice area' so runoff estimates includes snow melt from the glaciers. Panel A contains the unsmoothed data. Panel B shows data smoothed with a triangular filter, which weights the central point highest and considers 730 points (two years) on either side. Basins are color-coded: magenta is for the whole basin, blue is for the Dam basin, red is for the Cantwell basin, green is for the Denali basin, and cyan is for the Paxson basin. (reproduced from Wolken et al 2015, Figure 7.4.1-4)

<u>Need for Additional Information</u>

The FERC-ordered GRC literature study clearly establishes that warming temperatures are already having an impact on glaciers and streamflow in Alaska, and that modeling methodologies exist to investigate the consequences of projected temperature and precipitation changes on glacial runoff and on streamflow specific to the Susitna River drainage. The AEA modeling study (Wolken et al 2015) clearly demonstrates that one scenario of climate change has very significant impacts on the hydrology of the Project area and quantifies these results in a manner that can be used to inform the proposed Project and its operations. As Wobus et al (2015) discuss, the effects of likely non-stationary baseline conditions are significant for Pacific salmon from projected changes in flow that are dominated by a change in the timing of peak annual runoff. These changes are manifest in both increasing and more variable winter flows and the loss of the spring freshet. Because project operations are also expected to result in lower spring flows as the reservoir begins to fill and greatly increased and more variable winter flows, this study highlights our concern about the additive nature of both climate-induced and project-caused changes in flow and the inadequacy of current methods of determining baseline conditions absent consideration of climate change. NMFS requests that a range of plausible future climates and their impacts on hydrology be considered so that the risk to its trust resources be more fully quantified under high, medium, and low magnitudes of change. Therefore additional glacier and runoff change modeling is required. NMFS is primarily concerned with streamflow magnitude and timing, as well as water temperature and quality below the proposed dam, and how this will impact its trust resources. Increasing and more variable winter flows are predicted as a result of climate change, expected from project operations, and have occurred in recent years on the Susitna River. Effects of increasing and more variable winter flows could alter the balance between salmon egg burial depths and scour depths (Montgomery and Buffington 1996), potentially resulting in more frequent scour of redds during incubation (Tohver and Hamlet 2010). Depending on the magnitude of winter combined storm and project release-mediated flow events, entire year-classes of incubating salmon eggs could be lost. Conversely, project operations could be used to mitigate for the effects of winter storms. Therefore additional studies on streamflow, temperature and water quality are being requested.

These existing scientific advances provide an opportunity to improve long term project planning. The latest climate projections and downscaled climate change projections for the 50-year term of the proposed license, and potential future relicensing extending the life of the project, allow for assessment of the impacts of changing climate on the proposed project and the resources affected by the project.

FERC has typically relied on historical data and project-specific studies to evaluate project effects. Considering a static environmental baseline in project planning will not capture these projected changes, therefore, an analysis of projected changes in the climate and hydrology -- and subsequent ecological effects -- is needed for consideration in project planning. However, the best available science includes the presently observed and projected future impacts of climate change on water resources, as demonstrated by Congress directing the Secretary of Interior, via the Secure Water Act, to coordinate with NOAA and its programs to ensure access to the best available information on climate change [§9503 (c)(4) of the SECURE Water Act]. Seasonal climate prediction capability has also advanced, and may provide opportunities for enhancing operations on monthly to seasonal and annual timescales. Furthermore, the best available science standard does not require that information to be free from uncertainty. Nor does it require a higher degree of specificity, or fineness of scale in projections, than existing climate studies allow."

In summary, while there is a body of peer-reviewed, publicly available climate projections to work from, and numerous studies at regional and watershed-scale studies referenced above provide a valuable scientific foundation to understand this complex topic, they are not adequate to provide the detailed information necessary to understand: a) how climate change will influence the proposed Susitna Project facilities and operations; and b) how Project effects on beneficial public uses and public trust resources of the Susitna watershed will be altered under climate change; and c) what strategies might be necessary to respond to these effects.

Additional analyses of existing climate projections and their downscaled products is needed to assess climate impacts on the Susitna basin specifically, in particular, to understand the potential impacts of a range of projected climates, and to understand the impacts on flows and habitats downstream of the proposed project.

Unless we adequately address these gaps, any license issued in these proceedings will not adequately protect the public interest, and NMFS and other license participants including FERC, will not be able to adequately develop license terms and conditions to protect, mitigate and enhance Project-affected resources. To address these gaps, three additional steps are required. First, acceptable information needs to be developed, using current climate science, and generally accepted methods, related to the likely continued climate change effects to Susitna hydrology and the ecology of NMFS trust resources. Second, information needs to be developed that describes how the Projects will affect beneficial public uses in Project-affected river reaches. Third, effective license conditions or fish passage methods need to be identified and evaluated for adapting to, avoiding, minimizing or mitigating the effects of climate change. The study methods and analysis described below are designed to address the identified gaps.

<u>Nexus Between Project Operations and Effects on the Resource Studied:</u>
<u>How the Study Results would Inform the Development of License Requirements (§ 5.9 (b): 5.0)</u>

In its licensing proceedings, FERC must understand the range of variability around a hydrologic baseline by approving study requests that analyzed the magnitude, duration, frequency, and variability of available hydrologic records. Given the advances in science, FERC must now understand changing hydroclimatic conditions and the background effects of climate change on resources that will also be affected by the project in order to assess the effects of the proposed Susitna Project operations and to draft appropriate license articles. In addition to the documented warming climate conditions occurring in southcentral Alaska and the Susitna watershed, the proposed Susitna project will alter the magnitude, duration, frequency, and temperature of streamflow and river levels in the Susitna River below the dam, where the most of the critical fish habitat is located. These direct project effects, when combined with the warming associated with climate change, have likely detrimental effects to fish productivity for incubating, rearing and spawning anadromous and resident fish species (see Wobus et al 2015, Shanley and Albert 2014 and Leppi et al 2014). It is necessary to study how climate change is likely to affect habitat resources to predict how the fish resources may be stressed or may change their behavior.

NMFS is charged with sustainably managing trust resources including anadromous fish, endangered species, and their associated habitat including prey species. In the context of hydropower, this includes the ability to prescribe fish passage and consult with FERC to condition licenses to adequately protect these interests. Without the proposed hydropower facility at Susitna, NMFS would not have a need to assess conditions necessary for the continued management and passage of affected species because the watershed is remote and pristine and fish passage is unimpeded. Because NMFS is now required to determine existing and future needs of important trust resource in this system, throughout the life of the proposed license, and through NEPA for the reasonable life of the project, it is necessary to know if these environmental conditions are likely to change during this period. As described in this request, it is almost certain that environmental conditions will change. Furthermore, the science and downscaling of climate change models, glacial runoff, changing temperatures, and associated effects will allow assessment of the combination of the proposed reservoir and a plausible range of risks of future conditions to affected species, using methods consistent with generally accepted practice. This risk assessment, as described in the study request, will allow managers to plan needed license conditions. Therefore, there is a clear nexus between the construction and operation of the facility, the management of fish resources affected by the construction and operation of the facility, and the changing environmental conditions the fish exist in. In addition, many of the affected fish species are a major food source for an ESA listed species. With the information developed in this study request, NMFS can develop recommended license conditions that would effectively protect, mitigate and enhance our trust resources, by accurately accounting for the effects of climate change on anadromous fish and habitat resources that are additive to and exacerbated by the effects of the project.

Given the current trends (described above in existing information), there is need to document the environmental baseline of the project, and to develop a realistic projection of the range of potential future trends in order to effectively evaluate the impacts of the project on NMFS resources and allow NMFS to make accurate conservation recommendations, license terms and conditions, and to develop recommended protection, mitigation and enhancement measures to address likely project effects.

Without this understanding, FERC will be unable to make a licensing decision, order and condition a license that properly balances the factors that require assessment under Section 4(e) of the FPA, including the efficiency, longevity and cumulative ecological impacts of the proposed hydropower project and project operations. The agencies, including NMFS and FERC, should assess these particular effects given the reasonably close causal relationship between the environmental effect and the alleged cause (Public Citizen, 541 U.S. at 767).

This information on climate change is needed to inform the nexus between project operations and NMFS ability to inform our recommendations to FERC with regards to licensing the Project. This information includes a range of projected hydrologic changes informed by state of the art GCMs and downscaled climate projections, and detailed changes in hydrologic processes including glacier wasting, snowpack evolution, permafrost melting, streamflow volume and timing, and stream temperature, changes in riparian vegetation and evapotranspiration, and the ecological effects of those changes.

The Susitna River Basin's water resources are increasingly at risk from climate change. Thus, the proposed study is needed to connect the trends and projected changes in climate and hydrology to variables needed for project planning. The results of the study will provide data and a modeling framework for additional analysis of options to condition the license including:

- Informing the development and implementation of monitoring plans for streamflow, temperature and habitat quality;
- Contributing to the development of possible adaptive management components of a new license to mitigate the impacts of climate change and reservoir operations. These may also include climate and weather forecast-based reservoir operations.
- Assisting in timely identification and planning for possible modifications to management, operations (e.g. ramping rates), or infrastructure necessary to respond to or take advantage of climate change;
- Informing the implementation or interpretation of other study plans or results, including further water temperature monitoring and modeling, detailed identification of strategies for managing temperature of reservoir releases, and instream flows volume.

FERC has stated in past study requests that they are “not aware of any new information…. ,” the following sections describe the state of the science, and is intended to make FERC aware of the generally accepted practice of the use of such information by hydropower projects planning through other entities.

The Proposed Study Methodology’s Consistency

This section is provided because of the significant new information and changes in policies since the original request. In past licensing proceedings, FERC has voiced concerns that analyzing the effects of climate change under all alternatives would be too speculative given the state of science at this time (Enloe Project, Scoping Document 25/7/09) or that climate change models do not yet have the accuracy that would be needed to predict specific resource impacts and inform license conditions (York Haven Project, Revised Scoping Document 11/13/09; Conowingo and Muddy Run Projects, Revised Scoping Document 8/24/09; Yuba-Bear and Drum Spaulding Projects, Study Plan Determination 2/23/09). However, the state of climate science has advanced significantly, and climate models, typically downscaled with statistical methods or using regional modeling techniques are now routinely being used by non-federal and federal agencies and water utilities, including use for project level analysis (USFS 2009), and are included in the Council on Environmental Quality recommendations for NEPA analysis (CEO 2010). The concept of a stationary environmental baseline with fluctuations (high and low water years) around a relatively stationary mean (as previously used by FERC and other regulators) is an outdated concept given the current level of scientific certainty of climate change (Milly et al 2008; Viers 2011; Wobus et al 2015). Thus, as described in this section, current best practices for water management recommend moving beyond the concept of a stationary future, and consider a range of possible future scenarios, including those that are consistently represented in the GCMs and downscaled projections.

Since the time of the original 2012 study request, the generally accepted practice for hydropower, dam and water management projects in the United States (and around the world) has been evolving to consider projections of climate variability and climate change in project planning and operations. Therefore, the study methodology proposed considers the risks of climate change. To assume a static baseline could result in incorrectly attributing all resource changes to project operational causes, when a significant degree of resource effects are likely to be caused or exacerbated by climate change rather than by the project alone.

Many scientifically defensible, published, and peer-reviewed methodologies and practices have been developed and used by agencies to study the potential impacts on water supplies from climate change and to provide tools to resources managers to adapt to those changes (SECURE Water Act, Means et al 2010; Brekke et al 2009). Furthermore, the downscaled projection datasets and hydrology simulations recommended above for use in the study are all from peer-reviewed published research, and were developed for use in natural resource management, including water, including the studies described in this section. Studies articulating how to use the IPCC models, and the downscaled products based on their input, in water management include:

1. Guidelines on the use of climate scenarios developed from statistical and regional climate model experiments (Mearns et. al 2003; Wilby et al 2004).

2. Studies of the strengths and weaknesses inherent in the choice of downscaling methodology (e.g. Fowler et al 2007; Salathe et al 2007, Miller et al, 2009).

3. Assessment of the use of downscaled GCM historic simulations and future projections are for hydrologic and ecologic impacts studies of climate change (e.g., Brekke 2009).

4. Use of uncertain information in water utility planning (e.g. Barsugli et al 2012,Waage and Kaatz, 2011).

5. Methods to account for the bias in climate models, the spread of projected climate change, and to account for local circumstances (for example through downscaling or high-resolution hydrologic modeling) (Brekke et al, 2011).

6. Furthermore, numerous studies have developed methods to incorporate this uncertain information into long- term planning processes, and documented these methods and strategies in the peer-reviewed literature, including the need to shift from a “predict then act” framework described by Weaver et al (2013), and prevalent in FERC. They describe using climate knowledge as part of a shift to a risk framework (paradigm 2 in Weaver et al 2013).

7. Use of scenario analysis and planning as one method to deal with complex, uncertain systems, as reviewed in Brekke et al (2009, chapter 4). Traditional scenario analysis uses a small number of scenarios (Schwartz 1991). These scenarios could be defined relative to climate projections, demographic outlooks, and other planning drivers. Such scenarios might be cast as "top down," contrasted with "bottom up" scenarios (Ray et al 2008) that are defined within a sensitivity analysis where thresholds of operations flexibility are revealed by incremental adjustment of planning drivers. These approaches are not necessarily exclusive. Miller and Yates (2006) recommendations for using climate modeling in decision making include using the downscaled results in such a risk and scenario framework (Brekke 2009).

NEPA requires federal agencies taking certain actions to consider climate change impacts – those the agency's project may contribute to, and, as in this case, those affecting the proposed project – in the Environmental Impact Statement (EIS) [NEPA § 102(2)(C); 42 U.S. C. § 4332(2)(C)]. A study of the use of climate change information in EIS's found that, "Climate impacts in the project region are often discussed in order to consider their effect on a resource which the project might also impact," (Woolsey 2012, p 8). The study found that EISs for reservoir projects routinely analyze the potential impacts of climate change on water resources in detail, addressing decreased precipitation and runoff, and that this analysis predicted that several rivers will not be able to meet their minimum flow requirements and that water usage plans will need to be reevaluated. The author notes that U.S. Fish and Wildlife Service's EISs address the effects of climate change on the habitat, food resources and behavior of individual species, especially those federally listed as endangered or threatened (Woolsey 2012).

In the last several years, federal agencies have increasingly considered the risks of climate change (e.g. NMFS 2016 and Udall 2013). A growing body of U.S. policy requires and provides guidance on consideration of climate risks, and use of climate information by agencies. This guidance on consideration of climate risks has moved beyond that in EIS's initiated several years ago (Woolsey's study only considers EIS's complete through Dec 2011). In comments for the Draft EIS for the Middle Fork American River hydroelectric license, the Environmental Protection Agency (EPA) rated the Draft EIS as having provided insufficient information, in part, because it did not address potential cumulative effects of climate change on the project area and how this may affect future conditions (EPA 2012). The *best available science* (Ray 2016) now includes the presently observed and projected future impacts of climate change on water resources, as demonstrated by Congress directing the Secretary of Interior, via the Secure Water Act, to coordinate with NOAA and its programs to ensure access to the best available information on climate change [(§) 9503 (c)(4) of the SECURE Water Act.

Specific federal policy guidance on the use of climate projections includes, beginning in 2009, and continuing since our original 2012 study request:

1. Executive Order 13514 (2009), Section 8(i) required that as part of the formal Strategic Sustainability Performance Planning process, each federal agency evaluate agency climate change risks and vulnerabilities to manage both the short- and long-term effects of climate change on the agency's mission and operations. Another section, Sec. 16., articulates Agency Roles in Support of the Federal Adaptation Strategy. The Council on Environmental Quality (CEQ) Climate Change Adaptation Task Force issued implementing instructions for the strategy in March, 2011 (CEQ 2011). This E.O. was replaced by E.O 13693, described below.

2. The U.S. Forest Service (USFS) has recommended consideration of climate change in project level NEPA analysis (USFS 2009), and in a letter to the Forest Service National Leadership Team dated February 15, 2008, Forest Service Chief Abigail R. Kimbell characterized the Agency's response to the challenges presented by climate change as "one of the most urgent tasks facing the Forest Service," and stressed that "...as a science-based organization, we need to be aware of this information and to consider it any time we make a decision regarding resource management, technical assistance, business operations, or any other aspect of our mission."

3. In 2011, the U.S. Bureau of Reclamation and the Army Corps of Engineers released a report that identifies the needs of local, state, and federal water management agencies for climate change information and tools to support long-term planning (Brekke et al 2011). In the accompanying press release, Reclamation Commissioner Michael Connor is quoted, "Climate change impacts to water and water - dependent resources challenge water management agencies throughout the country,"… Close collaboration by water resource managers and scientists will improve the tools and information needed to help make future decisions that support the sustainable use of water." The U.S. Army Corps of Engineers Director of Civil Works, Steve Stockton, is also quoted, "This document takes a step toward communicating a collective expression of needs from the water resources community to the science community, ...we hope the science community will rally around these needs with collaborative research and fill the gaps that have been identified." (http://www.usbr.gov/newsroom/newsrelease/detail.cfm?RecordID=34803).

4. The U.S. Bureau of Reclamation also issued a "planning directive," Manual CMP-0902, signed 09/13/2012, that states, "The potential impacts of climate change will be considered when developing projections of environmental conditions, water supply and demand, and operational conditions at existing facilities as part of the without-plan future condition."

5. The Department of Interior Climate Change Adaptation policy (DOI 2012) effective, 12/20/12.

6. The Bureau of Land Management's National Operations Center is requiring study of climate change as a "change agent" in each of its "Rapid Ecoregional Assessments," (http://www.blm.gov/wo/st/en/prog/more/Landscape_Approach/reas.html)

7. The Executive Order 13690 (2015) on Planning for Flooding requires that elevation and flood hazard area be defined in a study using a climate-informed science approach that uses the best-available, actionable hydrologic and hydraulic data and methods that

integrate current and future changes in flooding based on climate science. (https://www.whitehouse.gov/the-press-office/2015/01/30/executive-order-establishing-federal-flood-risk-management-standard-and-)

8. Executive Order 13693, Planning for Federal Sustainability in the Next Decade, was signed by President Obama on 19 March 2015. This Executive Order revokes a previous Executive Order 13514 (5 October 2009), but further expands agency interests in climate change resiliency and preparation. According to the 13693 implementation guidance, agencies are required to annually update Strategic Sustainability Plans describing specific agency strategies to accomplish, *inter alia*, the consideration of the effects of climate change on the agency's operations and programs.

9. The Aug 2015 NOAA Fisheries Climate Science Strategy identifies a number of ways NOAA should incorporate climate science into operations and policy (Link et al 2015.). This includes Objective 7: Build and maintain the science infrastructure needed to fulfill NOAA Fisheries mandates under changing climate conditions. It also suggests designing scientifically sound review-evaluation protocols that could ensure consideration of climate change as a standard part of living marine resource management advice.

Water managers and planners outside the federal government are also considering risks of climate change and incorporating this in their long-range planning. The Water Utility Climate Alliance (WUCA), ten of the Nation's largest water providers, formed to provide leadership and collaboration on climate change issues affecting the country's water agencies. In January 2010, WUCA released a white paper that "outlines planning approaches to help water utilities adapt to climate change. Planning methods are necessary because many water utilities cannot afford to delay significant decisions and wait until the range of potential climate change impacts is substantially narrowed." The report, "Decision Support Planning Methods: Incorporating Climate Change Uncertainties into Water Planning," was produced to help water utilities consider and evaluate traditional and emerging planning techniques for use in their own climate adaptation efforts. WUCA and its member cities have continued their interest in the use of projections, including a set of case studies in how climate change is shifting water utility planning (Stratus Consulting and Denver Water 2015) and about producing actionable climate information for utility modeling applications (Vogel et al 2015).

Thus, the requested analyses of climate projections is consistent with generally accepted practice, as well as their use in in a risk assessment framework, including the consideration of a range of plausible risks, is now the generally accepted practice in the scientific and management community, supply and infrastructure planning processes, by federal and non-federal water management, resource and infrastructure planning the U.S. and the world.

Considerations of Level of Effort and Cost for the Study Modification

Although cost considerations aren't typically included in a study modification, we are including it because cost was a concern of FERC in the original request. This proposed study is estimated to require a one-year study involving ~1.3-2 person years of effort including a primary investigator with preferably post-doctoral experience the field of applied climate projections to design and direct the study, along with assistant researchers capable of conducting portions of the study's different topics. A lower level of effort (~1.3 person-years) is feasible if there are existing datasets available and deemed appropriate as input for all the elements described above; if not, a higher level of effort as reflected in the following estimates may be required.

Our estimate of time needed includes augmentation of the literature assessment of existing climate, water and hydropower studies (Request Element 1, estimate 1 person-month (p-m)), acquiring and analyzing downscaled projections of climate and performing glacial and hydrologic modeling (Request Elements 2 and 3, total 6-8 p-m), develop projections for streamflow, water temperature and quality below the proposed Project (Request Element 4, 6-12 p-m), producing a technical report, data and archiving and availability, and coordination (Request Elements 5 and 6, 2-3 p-m). The main uncertainties in this estimate include: suitability and availability of new dynamically downscaled projections (Element 2), and whether existing or new modeling is needed for Element 4. If effort were needed on these models and data analysis and documentation, the effort would expand to ~2 person years, and also need to provide for funds to support the computing needed for dynamical downscaling. This year of study is estimated to cost between $250,000 to $350,000. This is a very cost-effective expense.

Finally, FERC states that the cost of such a study is not commensurate with the information they may yield. Curiously, despite the fact that the applicant had elected to fund and conduct the study, and FERC's statement that FERC would use information from this study in its licensing decision, FERC also determined that the study was too costly. However, this appears to be a very cost-effective expense both in the context of the cost of the project and the commercial value of the natural resources. In the case of Susitna, current projected cost of the facility are about $5.8 billion, plus the costs of needed upgraded transmission lines, and the costs to modify FERC licenses for all other FERC-licensed hydropower projects in the Alaska Railbelt electrical grid, whereas the study costs are $250,00-300,000. Cook Inlet and the Susitna Basin contain some of the largest and most valuable salmon habitat and fisheries in the world and the Susitna is home to the 4th largest Chinook Salmon run in Alaska. The Susitna River is one of the largest salmon producers in upper Cook Inlet fisheries, supporting both local communities and Alaska's overall commercial fishing infrastructure. Upper Cook Inlet's average commercial harvest is four million salmon annually with an estimated ex-vessel value (value before processing) in 2012 of approximately $34.2 million. (ADFG 2015) Residents and non-residents spend a combined

300,000 angler-days (or days spent fishing by one person) in the Mat-Su Borough, primarily on Susitna's tributaries. A study completed for the Matanuska-Susitna Borough by University of Alaska Anchorage Institute for Social and Economic Research found that spending related to sport- fishing for residents and non-residents generated between 900 and 1,900 local jobs and between $31 million and $64 million of personal income for people in the borough (Colt and Schwoerer 2009). Lake and stream systems within the Susitna drainage are key spawning and rearing habitats for much of the Upper Cook Inlet Sockeye Salmon run, the most commercially valuable of the salmon runs.

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8.5 Instream Flow

ISR Review and Study Modifications

The goal of the Fish and Aquatics Instream Flow Study is to characterize and evaluate the proposed Project's potential operational flow-induced effects on fish habitat below the proposed Project dam. The study's implementation focus is on establishing a set of analytical tools/models based on site-specific channel and hydraulic data that can be used for defining existing conditions (i.e., without Project) and how these resources and processes will respond to alternative Project operational scenarios.

The Instream Flow Study Report (as supplemented by Interim Study Report (ISR) Part D for Study 8.5 and the corresponding 2014–2015 Study Implementation Report) addresses the Instream Flow Study analytical framework; river stratification and study area selection; hydrologic data analysis; reservoir operations model and open-water flow routing model (OWFRM); hydraulic modeling; habitat suitability criteria development; habitat specific flow-habitat modeling; temporal and spatial habitat analyses; and instream flow study integration.

The following documents were reviewed and will be referenced related to the Integrated Licensing Process ISR process for the Instream Flow Study (8.5):

- Fish and Aquatics Instream Flow Study (Study 8.5) ISR: Part A (Sections 1-6, 8-9), Part B (Supplemental Information and Errata to Part A), and Part C (Executive Summary and Section 7)
- Fish and Aquatics Instream Flow Study (Study 8.5): 2013-2014 Instream Flow Winter Studies Technical Memorandum
- Fish and Aquatics Instream Flow Study (Study 8.5): Evaluation of Relationships between Fish Abundance and Specific Microhabitat Variables Technical Memorandum (September 17, 2014; this document has been superseded by Part D, Study Implementation Report (SIR), Habitat Suitability Criteria Development, Appendix D).
- Fish and Aquatics Instream Flow Study (Study 8.5): 2013-2014 Instream Flow Winter Studies Technical Memorandum Addendum
- Fish and Aquatics Instream Flow Study (Study 8.5): ISR Part D: Supplemental Information to June 2014 ISR
- Fish and Aquatics Instream Flow Study (Study 8.5): 2014-2015 SIR: Appendix D, Habitat Suitability Criteria Development
- The Alaska Energy Authority's (AEA) "Initial Study Report Meetings March 24, 2016 Action Items," as it pertains to Fish and Aquatics Instream Flow Study Plan Section 8.5.

Study Objectives

The objectives of the Fish and Aquatics Instream Flow Study, as specified in the ISR, Section 8.5 include the following:

1. Map the current aquatic habitat in main channel and off-channel habitats of the Susitna River affected by Project operations. This objective will be completed as part of the Characterization of Aquatic Habitats Study (9.9) (see Figure 8.5-1).
2. Select study areas and sampling procedures to collect data and information that can be used to characterize, quantify, and model mainstem and lateral Susitna River habitat types at different scales. This objective will be completed via a collaborative process involving this study, Riparian Instream Flow (8.6), Groundwater (7.5), Geomorphology (6.0), Water Quality (5.0), and Fish and Aquatics (9.0).
3. Develop a Mainstem OWFRM that estimates water surface elevations and average water velocity along modeled transects on an hourly basis under alternative operational scenarios.
4. Develop site-specific Habitat Suitability Criteria (HSC) and Habitat Suitability Indices (HSI) for various species and life stages of fish for biologically relevant time periods selected in consultation with the Technical Working Group (TWG). Criteria will include observed physical phenomena that may be a factor in fish preference (e.g., depth, velocity, substrate, embeddedness, proximity to cover, groundwater influence, and turbidity). If study efforts are unable to develop robust site-specific data, HSC/HSI will be developed using the best available information and selected in consultation with the TWG.
5. Develop integrated aquatic habitat models that produce a time series of data for a variety of biological metrics under existing conditions and alternative operational scenarios.
6. Evaluate existing conditions and alternative operational scenarios using a hydrologic database that includes specific years or portions of annual hydrographs for wet, average, and dry hydrologic conditions and warm and cold Pacific Decadal Oscillation (PDO) phases.
7. Coordinate instream flow modeling and evaluation procedures with complementary study efforts including Riparian (8.6), Geomorphology (6.5 and 6.6), Groundwater (7.5), Baseline Water Quality (5.5), Fish Passage Barriers (9.12), and Ice Processes (7.6) (Figure 8.5-1). If channel conditions are expected to change over the license period, instream flow habitat modeling efforts will incorporate changes identified and quantified by riverine process studies.
8. Develop a Decision Support System-type (DSS) framework to conduct a variety of post-processing comparative analyses derived from the output metrics estimated under aquatic habitat models. These include (but are not limited to) the following:
   - Seasonal juvenile and adult fish rearing
   - Habitat connectivity
   - Spawning and egg incubation (habitat persistence)
   - Juvenile fish stranding and trapping
   - Ramping rates
   - Distribution and abundance of benthic macro-invertebrates

The following overarching change applies to most objectives in 8.5 and many of the other studies:

- Minimum two additional consecutive years of data collection for integrated riverine and physical process studies; and water quality and biologic studies in each Focus Area (FA). This data is necessary to populate and test predictive capabilities of aquatic habitat models for spawning and rearing fish.

NMFS Study Modifications

In this numbering scheme the objective is listed first, followed by the modification (i.e. 2-1 is the first modification to objective 2, 2-2 is the second modification). The National Marine Fisheries Service (NMFS) recommends the follow study modifications:

2-1: Surveys to locate salmon spawning and rearing habitat in the lower river be completed and representative FAs should be identified similar to the middle reach.

2-2: Measurement of ice thickness, water depth, water temperature and water velocity at multiple points along 10 or more transects in each FA are needed to accurately model ice thickness and calibrate and validate winter hydraulic models (ISF 8.5 and Ice Processes (7.6)).

3-1: The applicant should provide details of what discharges ILF-1 will actually release and example ramping rates. NMFS recommends water surface elevations be modeled with the most up to date OWFRM using these discharges.

3-2: Additional operational scenarios be developed and evaluated, including the evaluation of the run-of-river scenario that was required by the Federal Energy Regulatory Commission (FERC).

3-3: HEC-RAS model input and output files should be provided to stakeholders as the data is needed to conduct an independent verification of conclusions made by AEA regarding the downstream extent of Project impacts as a result of proposed operational flow scenarios.

3-4: The mechanism for integrating operational scenarios with other study disciplines is needed to evaluate the utility of ISF modeling efforts.

4-1: The habitat criteria are surveyed with regard to the Project’s hierarchical habitat model, according to the approved plan study.

4-2: The criteria (HSC) must be analyzed according to the Project’s hierarchical habitat model and HSC must be developed for individual macrohabitats.

4-3: The habitat criteria must be surveyed with respect to the distribution and periodicity of fish species and life stages present on the river.

4-4 The surveys of available habitat are performed in habitats similar to those occupied in order for ecologically and statistically valid comparisons to be made

4-5 AEA design their HSC study to compare the dependence of fish habitat selection on vertical hydrologic gradient (VHG). This can only be accomplished by surveying habitats with a different VHG.

4-6 AEA analyze their data in accordance with their proposed and approved hierarchical habitat model.

4-7 FERC determined (4/1/2013) that AEA must evaluate microhabitat criteria by comparison and examination of relationships between abundance and microhabitat criteria. AEA must evaluate the statistical and ecological relevance of these relationships using statistical methods

4-8 Develop macrohabitat specific utilization models (HSC/HSI) for open and ice covered (winter) periods for fish species and life-stages.

4-9 Increase replicates of macrohabitat observations for winter studies to be consistent with resource agencies request during the study plan development.

4-10 HSC/HSI curves should be developed for fish behavioral response to short-term flow fluctuations (i.e., ramping) under the proposed OS-1b/ILF-1.

5-1 Increase sampling effort of subsurface water temperature and DO measurements at each FA to address Chum Salmon incubation. Subsurface water temperature and DO data should be integrated with the 3D groundwater models to develop HSC curves and WUA analyses.

5-2: Compile a comprehensive aquatic habitat model water quality report of interdisciplinary data collection efforts. This should include all QA/QC procedures and results (calibration dates, quality objectives, accuracy and precision calculations) as part of the ISF (8.5) study, or Water Quality (5.5, 5.6, 5.7) studies or new Model Integration study.

5-3 NMFS recommends breaching flows and habitat connectivity analysis should be conducted on biologically relevant timelines; such as every 5 years, which is the average generational lifespan of a Susitna River Chinook Salmon.

5-4 NMFS recommends that AEA describe and then predict the extent of warmer winter aquatic habitats that have not previously been seen on the Susitna.

5-5 NMFS recommends that the uncertainty that results from the analysis of aquatic habitat models should be transparent to stakeholders to understand limitations of each model used to assess potential project effects.

5-6 Thoroughly address the ability to model stranding and trapping under the rapid and perpetual flow fluctuations in side channels and side sloughs during proposed winter flows.

5-7 Address the need to provide habitat persistence for holding (e.g., at river mouths) and over wintering fish species by developing thresholds for lateral and longitudinal geomorphic habitat change and connectivity and alterations to the hydrograph.

6-1 Other operating scenarios, including run-of-river, be evaluated and their effect on habitat availability be assess under various Pacific Decadal Oscillation scenarios. These alternative operating scenarios could be used as protection mitigation and habitat conservation (PM&E). This recommendation is similar to 3.3 but it recommends completing the suite of evaluation steps that come once the OWFRM has been run.

7-1 This objective can best be met by developing a New Study request for model integration. This request is included in this filing.

7.2 In a single "pilot area" (probably an existing FA) run/coordinate all the current models and show the amount and quality of various fish habitats over the next 50 years for two operating scenarios (full load following and one other) and no project scenario.

8-1 This objective can best be achieved by implementing a New Study for Model Integration and DSS. This New Study Request is included in this filing as an enclosure.

8-2 The applicant produce tallies of different macro, meso, and micro habitats weighted by "value" to various organisms for each proposed alternative as is usual in the aquatic habitat approach. Emphasis should be on how the various modeling efforts can produce side-by-side comparisons of Project alternatives (including a no-Project alternative).

Background

AEA proposed the use of hydraulic habitat modeling to characterize existing flow-habitat relationships for priority fish species within the habitat mosaic of the Susitna River floodplain. Hydraulic habitat modeling is a general term. The specific tool/framework used by AEA follows the Instream Flow Incremental Methodology (IFIM) developed by the U.S. Geological Survey (USGS) (Bovee et al. 1998) through the application of one-dimensional (1D) and two-dimensional (2D) hydrodynamic modeling and species-specific habitat suitability curves (HSC). Habitat-based modeling requires the development of habitat suitability criteria (HSC) that are used to develop curves for modeling habitat selection (suitability) as a function of microhabitat. Microhabitat, in hydrodynamic modeling, is universally represented by surface water depth and velocity, by necessity. These criteria can be conditioned by the presence/absence of other channel characteristics, but surface water hydraulics drive hydraulic habitat simulations. The development of reliable habitat suitability criteria is critical to the successful implementation of the IFIM, or other habitat-based evaluation technology.

In large alluvial floodplain channel networks, a complex hierarchy of surface and groundwater hydraulics and water quality influences salmonid habitat selection. Secondary habitat characteristics, such as primary and secondary production, can also be influential. This diverse habitat mosaic contains a set of recurring habitat types that were viewed as macrohabitat units. Local microhabitat conditions manifested within each of these macrohabitats are remarkably distinct. Microhabitat also differs among the mesohabitats represented within each macrohabitat.

Within the Susitna River's habitat mosaic, AEA attempted to identify microhabitat criteria that were ecologically relevant to habitat selection. AEA then used those criteria to 1) develop HSC curves that represent the ranges of utilized parameter values for each criterion and 2) predict the probability of utilization within these criteria values. In order to determine the appropriateness of an IFIM habitat-based evaluation and identify what microhabitats were ecologically relevant to habitat selection, the NMFS requested a holistic evaluation of microhabitat criteria.

Thus far, questions regarding the HSC developed and proposed for this project have prevented discussions with stakeholder to advance beyond this stage. Unless valid criteria can be identified, HSC curves cannot be developed or evaluated. Without realistic HSC curves, habitat availability cannot be modeled, as a function of flow. If habitat cannot be modeled as a function of flow, flow-habitat relationships cannot be predicted in space and time, model integration is impossible, and no environmental assessment can be accomplished. Because this is how AEA proposed to evaluate the effects associated with this project, the environmental assessment cannot proceed further.

Within this particular area of study, significant issues remain in the context of AEA's study design and analyses of HSC data. AEA's study design and data analyses procedures prevented an ecologically valid process for identifying relevant habitat criteria and model development. These procedures and the lack of information needed to assess the proposed models, or the criteria they rest upon, also prevented the assessment of HSC on a statistical basis. As it currently stands, it is NMFS that the HSC study was inadequate, given the objectives and determinations, and necessary information has not been provided to allow a full assessment.

The Services (NMFS and the U.S. Fish and Wildlife Service) made several requests to meet with AEA's consultants to discuss concerns regarding the HSC study design and analyses. This has not occurred. In September 2014 the Services requested a two day face-to face meeting with the consultants to discuss HSC development. The Services provided an agenda to help frame the discussion necessary to move forward with HSC development. AEA postponed scheduling this meeting until after the scheduled January 2015 ISR meetings (which were then also postponed). The Services then requested a two-hour teleconference with consultants for December 23, 2014 to discuss methods and analyses reported in the Evaluation of Relationships between Fish Abundance and Microhabitat Variables Technical Memorandum (TM) (September 17, 2014). AEA canceled the December 23 meeting as a result of the Governor's Administrative Order (issued December 19, 2014) halting all spending on the Susitna Project. Additionally, after the recent ISR meetings, held in March 2016; AEA requested a meeting with the Services to discuss the HSC study, due outstanding questions remaining. AEA cancelled this meeting.

Flow-Habitat Modeling

A hydraulic habitat evaluation or flow-habitat modeling involves two primary components, hydraulic and habitat simulation. Hydraulic models are utilized to simulate river hydraulics, as a function of flow, and HSC translate these estimates into habitat. These microhabitat simulations and habitat translations are performed within hydraulic modeling cells. The output of a flow-habitat analysis is weighted usable area (WUA). WUA is a habitat measure combining the quantity (area) and quality of habitat, based on surface water hydraulics, within modeling cells. Weighting is the procedure that governs the length of the modeling cells, and hence the overall area of habitat represented by each cell. WUA is simply the product of the area of each computational cell and the combined suitability of each cell, as determined by HSC modeling. WUA is expressed in terms of habitat area for a given stream length, typically 1,000 feet. It is given by the following general expression, on a cell-by-cell basis:

$$WUA = \Sigma A_i * C_i$$

Where: WUA = Weighted Useable Area
A = view area of the modeling cell
C = the composite suitability of the cell; hydraulics translated by HSC

While a hydraulic habitat evaluation can, in certain settings, serve as a useful tool for evaluating alternative flow scenarios, it cannot be applied without adequate consideration of its appropriateness. According to USGS[1], a simple hydraulic habitat analysis such as conducted in PHABSIM is only appropriate (realistic) when habitat is limited by surface water hydraulics used to represent habitat. Users must demonstrate that habitat is primarily a function of depth and velocity. If users cannot perform this demonstration, project stakeholders must be willing to make this assumption. NMFS does not agree that this is a valid assumption and instead requested a scientific process through which habitat criteria can be weighed according to their ecological relevance.

AEA described HSC/HSI as curves that translate hydraulics into habitat suitability, based on assumptions made about functional relationships. These assumptions were made in the place of scientific assessments of biological/ecological relevance, necessary to discriminate between which HSC/HSI should be used to estimate habitat, as a function of flow. For a project of this scale, with the resources involved, these assumptions of ecological relevance leave stakeholders with great uncertainty about the AEA's ability to develop realistic flow-habitat relationships needed to characterize existing conditions for the proposed project. NMFS does not support making untested assumptions about habitat criteria and HSC upon which AEA has proposed to base their entire assessment of the Project. Modifications to the HSC study must be implemented prior to a successful demonstration of the appropriateness of PHABSIM/2D Habitat Modeling for assessing flow habitat relationships for this Project.

[1] Waddle, T.J. (ed.). (2012) PHABSIM for Windows user's manual and exercises. Open-File Report 2001-340. Fort Collins, CO: U.S. Geological Survey. 288 p.

Temporal and Spatial Habitat Analyses

Temporal and spatial habitat analyses have not yet been performed, nor can they be until successful modifications to the HSC study are incorporated. The supplemented ISR provides an update of AEA's development of integrated aquatic habitat models to produce a time series of biological metrics data (pertaining to fish life history strategies). The metrics would then be used to conduct a habitat-based evaluation of Project effects under existing conditions and alternative operational scenarios. In order to synthesize the multitude of results from the habitat-based evaluation, AEA described their general approach to develop a Decision Support System-type (DSS) framework to conduct a variety of post-processing comparative analyses derived from the biological and hydrological output metrics estimated under the aquatic habitat models.

There are several weak points, as proposed, in the effective combination of quantified fish response curves, measurement of physical conditions, and ability to predict physical conditions under Project alternatives that will be required to implement a future habitat-based evaluation. Representing uncertainty in the effective combination of models, analysis, assumptions and measurements has no simple or satisfactory solution. At the most general level the study tried to evaluate alternatives in a multiple variable realm of possible outcomes associated with each proposed Project operational alternative. Precision and accuracy in measurements, parameters, and specific feasible model outputs are important and deserve attention and reporting. Fundamental spatial and temporal variation and the relevance of chosen model variables are even more important. For example, a precise and accurate estimate of habitat at a single site at a specific discharge and current channel geometry is not as relevant as some estimate of habitat at multiple locations under multiple possible sequences of discharge that might occur under a given operational alternative—further considering the multiple possible channel geometries associated with each sequence of discharges.

At this point, the feasible, but incomplete approach, is directed at estimates of output variables (such as habitat suitability for a particular species and life stage) under a set of specified cases defined by study site, hydrology, and channel geometry; such as, study sites (ten FAs) under 3 different discharge year-types (wet, average, dry) under 3 different possible channel geometries (present, 25 year and 50 year). From a practical perspective that is 90 different cases/simulations for each proposed operational alternative. It is not clear from the ISR how all of this information will be integrated into a final analysis of Project effects and if the analysis will provide an appropriate representation of important spatial and temporal variation in geometry, river network position, groundwater, temperature, ice formation, mechanical ice breakup, intra-annual timing of discharge and stage, and the long-term signature of extreme events. In addition, the limited scenarios and the integration of current model capabilities do not address the uncertainty surrounding concerns for fish species and life stages, invertebrates, and plants that have been a critical element of responses to dam construction and operation throughout the world. The estimates from each case are not really random samples of all possible outcomes, but at least can be plotted on the same graph with different colored symbols to be able to compare the variation that the proposed operational scenarios might have on instream flow habitat.

Project operational alternatives need to be compared realistically and appropriately. NMFS is most interested in the rank order of alternatives and their general absolute magnitudes; however we also do not want to end up with the relatively best habitat amongst a set of habitat values all producing extirpation. We also do not want an alternative which is clearly the best under representative wet, dry, and normal years, but that produces a terrible result if we are wrong about the role of ice in channel change or ignore the trajectory of channel change that might be triggered by an unusual sequence of years. NMFS recommends focusing the cases examined and portrayed to a mixture of (1) those that are most likely or representative, and (2) those that might result in the biggest differences in the absolute magnitude and rank order among the alternatives.

Instream Flow Study Integration

As with Temporal and Spatial Habitat Analyses, the Instream Flow Study Integration process has not yet been conducted. It should be noted that significant steps have been made to consider model integration sooner and more explicitly. As a result, the overall effort appears to be on a path that is better than what was originally proposed in the FSP of waiting until all final study results were completed before seriously considering exactly how to integrate models and analyses across studies (spatially and temporally). This integration component and DSS tool development has been a common, ongoing concern of stakeholders. Through numerous TT meetings, TWG meetings, and the Proof of Concept (POC) meeting, those conducting the ISF studies are making a promising and substantial effort to develop an integration strategy. However, improvements are much needed to assess Project impacts on Susitna River aquatic species including the following,

- Sampling of unaltered winter flow and hydraulic conditions through, under, and around ice
- Evaluation of winter physical habitat conditions for aquatic species
- Species/life stage sampling and observations throughout the year; periods of sampling did not adequately represent the periodicity of species and life stages that were developed for the project.
- Water quality and groundwater data collection and modeling efforts need to be better aligned with the spatial-temporal scale of fish production and instream flow studies to be useable.
- Discussions with stake holders related to data analysis and integration of:
- Aquatic species/life stage specific habitat parameters (i.e., groundwater, water quality), model development, testing and validation
- Spatial and temporal scales of model inputs and resultant model output and analysis
- Data accuracies and error propagation through models
- DSS development and a detailed understanding of data analysis, model interdependencies and outputs utilized to evaluate the potential operational flow-induced effects on fish habitat below the proposed Project dam

Review by Objective

Objective 1: *Map the current aquatic habitat in main channel and off-channel habitats of the Susitna River affected by Project operations.*

This objective will be completed as part of the Characterization and Mapping of Aquatic Habitats Study (9.9).

FERC Study Plan Determination (SPD) comments: FERC evaluated Objective 1, river stratification and habitat classification system for aquatic studies, including consideration of microhabitats nested within mesohabitats. Our review and recommendations for Objective 1 of ISF (8.5) are included in our review of Characterization and Mapping of Aquatic Habitats (9.9) ISR.

Evaluation of this objective and study modifications to the habitat mapping will be listed under Study 9.9

Objective 2: *Select study areas and sampling procedures to collect data and information that can be used to characterize, quantify, and model mainstem and lateral Susitna River habitat types at different scales. This objective will be completed via a collaborative process involving this study, Riparian Instream Flow (8.6), Groundwater (7.5), Geomorphology (6.0), Water Quality (5.0), and Fish and Aquatics (9.0).*

FERC Study Plan Determination (SPD) comments: In the study plan determination (SPD) (4/1/2013) FERC states that, *"AEA's approach to select a minimum of one Focus Area (FA) within each geomorphic reach is consistent with the intent of their habitat classification system and sampling framework, and should facilitate the meaningful extrapolation of results. This is common practice when stratifying based on physical characteristics and processes, and is appropriate for evaluating aquatic resources over broad spatial scales (Section 5.9(b)(6)).*"

In addition, FERC suggests that FAs are intended to be sites where intensive interdisciplinary studies are proposed, and therefore, require broader consideration than salmon production alone.

FERC recommended that AEA: (1) consult with the TWG and select an appropriate FA within MR-2 to eliminate from the study; (2) consult with the TWG and establish an additional FA in geomorphic reach MR-7 that is sufficient for conducting interdisciplinary studies, possibly near Lower McKenzie Creek or below Curry on old Oxbow II; and (3) file a detailed description of the changes to the proposed FA locations in MR-2 and MR-7 by May 31, 2013, and include in the filing documentation of consultation with NMFS, NMFS, and ADFG, including how the agency comments were addressed.

<u>Methods for Objective 2</u>

Proposed Methods: AEA stated that FA selection was to be based on: (1) mainstem habitat types of known biological significance (i.e., where fish have been observed based on previous and/or contemporary studies); (2) locations where previous sampling revealed few or no fish (i.e., FA-

141 at Slough 17); and (3) representative side channels, side sloughs, upland sloughs, and tributary mouth habitats.

Implemented Methods: Ten FAs were selected within the Middle River prior to the FERC Study Plan Determination (SPD). In response to FERCs recommendation in the SPD, AEA modified the location of one FA in consultation with the Technical Working Group (TWG). The consultation also resulted in the addition of Oxbow One (FA-113), to the Middle River segment at MR-7. The rationale for the Middle River addition was due to the relative size and importance of the geomorphic reach.

The ISR reports incomplete sampling across FAs during 2013 and inconsistent sampling efforts within individual FAs sampled. For example, the Groundwater study (7.5) proposed to collect input data to allow modeling of surface water-groundwater exchange in areas of ecological importance. The relevant ecological importance was to be determined by field efforts.

Variances for Objective 2

The sampling design used to collect data for characterization, quantification, and modeling of mainstem and lateral habitat types of nested scales within FAs was a variance during 2013.

Incomplete and inconsistent sampling of FAs is a variance to the approved Study Plan. Groundwater studies are focused mainly in FA-128 (Slough 8A in MR-6) and FA-104 (Whiskers Slough in MR-8) only, and conclusions regarding groundwater in FAs rely more on 'expert' opinion than from results of rigid sampling design of field measurements from the FAs. The RSP identified that meso- and microhabitat data would be collected/identified on-the-ground in conjunction with the HSC and fish distribution and abundance study to assist in ground-truthing the mesohabitat classifications identified by the 2012/2013 aerial mapping. However, the ISR states that this did not occur due to time constraints and that the microhabitat data would simply be linked to mesohabitat classifications obtained by the aerial mapping. If this is true, then there is no validation data available for the mesohabitat classifications. Similar concerns in the level of data collection efforts are noted for water quality (5.5, 5.6), ice processes (7.6), and fish and aquatics studies (9.5, 9.6, 9.7, 9.8. 9.9).

Restriction of land access during 2013 resulted in unequal sampling efforts across FAs in general. While land access was not available for the three upper FAs adjacent to CIRWG lands in 2013, this restriction was resolved in 2014 and AEA was able to complete detailed surveys in one of the three FAs (FA-151-Portage Creek) in September 2014. However, work on FA-173 (Stephan Lake Complex) and FA-184 (Watana Dam) was deferred. AEA suggested that not initiating studies in these FAs on a consistent timeline will not have a substantive effect on the completion of this study because all field work, data analysis and modeling will ultimately be completed prior to submittal of the license application. ISR 8.5 Part D and the SIR reports provide summary information for data collection efforts that occurred in 2014 at all 10 FAs.

The ISR, (Part C, 1 of 2) states that there will be two years of study for the three FAs located on CIRWG land. This is problematic because the 2013 data which constitutes year-one of study for the Susitna Watana Project had not yet been reviewed by stakeholders prior to 2014 field efforts.

In addition, NMFS is concerned with the potential for erroneous conclusions of data from comparative relationships among inconsistent hydrologic years and conditions across FAs (i.e., 2013 and 2014). AEA has created a temporal mismatch of data collection efforts. FAs were to provide detailed understanding of river processes by geomorphic reach. Two years of data does not allow for model validation with independent data, or model condition and variation under multiple hydrologic or biologic years.

Conformance with Objective 2

The intent of the FAs is to provide geomorphic reach specific biologic and riverine process data at macro-, meso- and microhabitat scales. The hierarchical habitats nested within FAs allows for relational understanding at multiple scales.

The primary purpose of the FAs is to integrate study disciplines to gain increased understanding of physical, chemical and biological habitat relationships. Objective 2 is designed to include data from study disciplines within FAs; including Riparian Instream Flow (8.6), Groundwater (7.5), Geomorphology and Fluvial Geomorphology (6.5, 6.6), Water Quality (5.5, 5.6), Fish and Aquatics (9.5, 9.6, 9.8, 9.9, 9.11, 9.12), and Ice Processes (7.6) studies. Integrated study data is intended to be input for 2D modeling efforts in FAs. Two dimensional (2D) modeling is expected to result in an increased understanding of modeled relationships under different operational scenarios over 1D modeling, given the channel complexity of the Susitna River. Middle River sampling efforts within and across FAs over multiple years need to be achieved to meet Objective 2. Study efforts during 2013 have consisted of a significant investment of time and resources, however many important data gaps remain.

- Adult salmon spawning distribution in the lower Middle River is unknown because of limited tagging effort and no tagging of Pink Salmon. Yet, Pink Salmon have been observed in Whiskers and Slough 6A and are an integral part of the ecology of the FAs.
- A Project demonstration of hydraulic flow routing and 2D modeling has been limited to within FA-8A.
- Groundwater studies are not adequate in scope and scale to provide comprehensive understanding at a scale relevant to fish.
- Data collection is occurring in one FA to develop a 3D model capable of predicting Project operational surface-groundwater exchange at a scale relevant to fish habitat.
- Water quality studies do not provide data for lateral off-channel habitats, and do not consider the influence of surface-groundwater exchange.
- Macro-invertebrate and productivity studies are only being conducted at a subset of FAs and only two FAs that overlap with salmon distribution in the Middle River.
- Fish passage studies have not been completed and rely on 2D modeling, which may not be robust enough to evaluate passage.
- The NMFS requests multiple, consecutive and concurrent years of data for relevant disciplines be collected across FAs to be used as model inputs.

For reasons discussed above, the NMFS considers Objective 2 to be underdeveloped. Below are recommendations to further study efforts toward ISF Study Plan conformance. Our recommendations pertain to topics addressed by FERC in the SPD or in the FERC-approved SP, but have not been sufficiently addressed. The recommendations are in response to our review of the 2013 information provided in the ISR, related 2014 Technical Memorandums, ISR meeting notes, and the ISR Part D and supplemental SIR documents. Modifications are additional information requests as a result of our overall agency review of these same materials.

Modification 2-1: NMFS recommends using results from the escapement study combined with new surveys to locate salmon spawning and rearing habitat to select representative FAs in the Lower River. FA study sites in the Lower River should represent the range of biological use of habitats. Results from the current adult escapement study should be used to identify representative spawning locations, and results from the 1980s or the current FDA study should be used to identify important juvenile rearing and overwintering locations.

In order to focus study efforts to quantify project effects on salmon you need to identify where in the lower reach those salmon are spawning and rearing. This modification is requested to ensure that Project effects on Lower River salmon spawning and rearing habitats are evaluated at known salmon spawning and rearing locations.

The selected Lower River study sites are locations that, in the 1980s, investigators believed may present fish migration barriers. These sites are not representative of the geomorphic reach, were not randomly selected, and are not areas of known spawning and rearing. Data analysis results from these locations were presented at the Proof-of-Concept (POC) meeting as an assessment of Project effects for rearing habitat. Instream flow analyses within the Lower River should occur at locations of known spawning and rearing habitat or critical sites. Selection of critical sites would be the most cost-effective method of evaluating Project effects on the Lower River. AEA stated that specific study site locations and transects within LR-2 of the Lower River will be selected and surveyed in 2016. Prior to conducting this work, AEA and their contractors should coordinate with the TWG and make sure that the locations and associated data being collected will be able to answer the study needs in the Lower River. Lower River study site selection is currently being based on the 1980s data that identified locations that were repeatedly used by fish. Rather than selecting sites from historical 1980s data, the NMFS would like the Project to use data from the fish distribution and abundance studies that occurred in 2012 - 2015 to identify current use within the Lower River.

While some interdisciplinary data has been collected in the lower river, the collection to date does not seem to follow a plan.

The lower river studies were not conducted as provided for in the approved study plan because, to date, they are not following a scientific plan.

Modification 2-2: Measurement of ice thickness, water depth, water temperature and water velocity at multiple points along 10 or more transects in each FA are needed to accurately model ice thickness and calibrate and validate winter hydraulic models (ISF 8.5 and Ice Processes (7.6)).

Modflow, River2D and to a lesser extent the Open-Water Flow Routing model (OWFRM 2.8) and River 1D need a large body of data so they can be calibrated and validated.

Ice thickness data is uniformly lacking in the FAs. Some water depth, temperature and velocity data exist for a few FA, but others have absolutely none, and most have an insufficient quantity to calibrate and validate models.

The studies were not conducted as provided for in the approved study plan because insufficient data exists to calibrate and validate the models.

Objective 3: *Develop a Mainstem Open-water Flow Routing Model that estimates water surface elevations and average water velocity along modeled transects on an hourly basis under alternative operational scenarios.*

FERC Study Plan Determination (SPD) comments: FERC (SPD April 1 2013; page B-96) did not request that this objective be modified.

Methods for Objective 3

The ISR and more recent 8.5 SIR discuss the reservoir operations model (HEC-ResSim and the newly identified MWH-ROM) development and calibration of the Open-Water Flow Routing model (OWFRM) (Version 2.0 and 2.8). AEA discussed and presented “proposed dam operations” but detailed description of operations are not in the ISR. Operational detail is critical information for determining the type and amount of spatial and temporal change that may occur due to Project operations and the effects on instream flow and habitat conditions. OS-1b and the more recently identified ILF-1 has been presented as a worst case operational scenario for load-following to demonstrate potential Project effects, however, realistic load-following operations that may occur have not been presented in detail. Information on how realistic load-following operations will be evaluated to minimize overall Project effects has also not been provided. Alternative operational scenarios should be identified, discussed, and potentially modified through TWG meetings to provide the best case scenario for both hydropower operations and species conservation. Although the reservoir operations model (MWH-ROM) is presented and development and calibration of the OWFRM (Version 2.0 and 2.8) were discussed in the ISR and most recent SIR, only results of the OWFRM associated with pre- and OS-1b post-Project operations were presented. Verification of modeling results was not provided, therefore; post-dam operation impacts could not be evaluated.

Hydrology and Flow Routing Version 2 (Technical Memorandum for ISR Part C- Appendix K): Because results from OWFRM 2.8 were not presented, we included our evaluation of results from version 2.0. Appendix K states that outputs from the OWFRM will provide fundamental input to the ice dynamics model. The ice process models will be used to simulate flow routing hydrodynamics during the ice-affected period. However, Appendix K does not describe how the OWFRM will provide fundamental inputs to the ice process model for that purpose.

The technical memorandum (Section 3.1) identifies the model channel geometry and calibration efforts for the HEC-2 model developed in the 1980s, but it does not include information on how the 1980s HEC-2 model was used to inform the current model.

Methodologies of discharge measurements are discussed (Section 3.1), but the ISR Technical Memorandum does not include any comparisons made between discharge measurements, or expected accuracy of the discharge measurements. Section 5.3.2 discusses measurement of profiles/panels of frazil ice but the effective depth for this measurement is not provided. It is not clear if the Project's definition of depth relates to the depth below the frazil accumulation or the depth below the ice cover.

Section 5.4.1.1.1 describes the combination of data inputs that were utilized to construct the cross sections for the OWFRM. The Technical Memorandum states that for the majority of cross sections that had split flow or side channels, the water surface elevation of the main channel differed from the secondary channels. To properly simulate the conveyance of water in the 1D HEC-RAS model, transects with multiple channels had to be altered in order to maintain the correct cross sectional flow area. As a result, 125 of the 216 cross sections (nearly two-thirds) had portions of the channel geometry outside of the main channel adjusted vertically. The vertical adjustment was based on the difference in water levels across the section, recorded on the day of the survey. The rational presented for this shift is due to the limitation of the 1D model, and that portions of the section must be adjusted to preserve the flow area. It is unclear if the vertical adjustments were based only on the concept of preserving flow, or if some were adjusted to match computed-to-observed water levels during the calibration process. Based on the methodology described, water levels in the back channel areas will require "post-processing", or readjustment for the provision of predicted water levels in the off-channel habitats for input/integration with complimentary studies. If these adjustments are in fact necessary, they may not be appropriate for other studies that rely on channel geometry for model input (e.g., river ice process model (7.5)).

Section 5.4.2.1 does not provide clear rationale or context for characterization of the referenced low, medium and high flows. The ISR Technical Memorandum should explain how these values compare to the flow duration values and threshold values of percentage exceedence used to determine low, medium and high flows. While the range of flows that were measured and used for model development and calibration for the three referenced flows was shown to have good coverage (80-83%), when looking specifically at the low flow ranges only 56% of the measured data fell within the specified "low flow" range. This raises some concern since the effective habitat in the Middle and Lower River are most affected by low flows. The ability to accurately predict the hydraulics along the river during low flow scenarios is crucial to determine Project effects on fish habitat.

The OWFRM was calibrated under steady-state conditions. AEA stated, "Under subcritical flows conditions found in the Susitna River, the water surface elevation at a given cross section is controlled primarily by the shape and water surface elevation of the next downstream cross section and to a lesser extent by roughness coefficients (Manning's n) and expansion/contraction loss coefficients (Section 5.4.2.1)." The context of this statement is not clear with respect to the model calibration. If downstream effects control the water level at a particular section then this further supports the more typical approach for calibration of Manning's n on a reach-by-reach scale. Section 5.4.2.1 describes an unfamiliar (atypical) [e.g., not using accepted scientific methods] OWFRM calibration method. Manning's n was calculated section by section to achieve a specified tolerance of 0.2 feet. Adjustments to Manning's n were limited to a specified range of values and where further adjustments were required, hydraulic control sections were synthesized and added downstream of the calibration section. These synthesized sections have uncharacteristic channel geometry compared to that of the originally surveyed (e.g., vertical shift of 2.6 feet and channel width increased by factor of 2). Based on the calibration results, the ISR Technical Memorandum Appendix does not describe the impact on the performance of other models that rely on geometry from the OWFRM (e.g., ice processes) or how well the models will perform for conditions that are outside of the range of flows utilized in the model calibration.

The discussion within Section 5.4.2.1 emphasizes that calibrated water levels are within a specified accuracy that is appropriate for assessing fish habitat. To meet this criterion, at a "calibration" cross-section, the water surface profile is adjusted by introducing an artificial control section with geometry that is inconsistent with the actual geometry. This method may achieve the desired effect at the "calibrations" cross section; however, the resulting accuracy of the computed profile throughout the reach of interest is not explained.

In Section 5.4.2.2, the methodology used to determine flow accretions for the unsteady flow calibration is different than that used for the steady-state calibration. Flow accretions are back-calculated based on the difference between the routed hydrograph and the measured hydrograph. We recommend a comparative illustration between computed versus observed hydrographs using both methods and with no accretion be provided. Discussion on the difference between the computed and observed hydrographs, including timing of peaks and flow continuity should be provided. The green line plotted in Figure 5.4-22 is not identified in the legend, making it unclear as to what information is being presented.

Section 6.4.2, states in reference to Figures 6.4-2 and 6.4-3 that, "Excellent agreement was found at Gold Creek and Sunshine, and good agreement was found at Susitna Station." The qualitative assessment appears to be based on a visual comparison of computed versus observed hydrographs. The Project's method for accounting for the flow accretions ensures an excellent fit because they are simply backing-out the difference between observed and computed hydrographs and then applying that difference upstream. This method is not a reflection as to how well the model performs in a predictive mode because it requires the observed data to predict that same observed data. In Section 6.4.3, Figures 6.4-5 through 6.4-7 the plot scale is difficult to discern between computed and observed hydrographs. We suggest that a more quantitative assessment of model validation be presented. For example, an assessment of associated error in water level corresponding to the error in the computed discharge is needed. How this compares to the calibration target of approximately 0.2 feet should be described.

Variances for Objective 3

Model calibration: The RSP stated that 13 mainstem water-level recording stations were to be installed to provide data for calibration of the OWFRM. The ISR states that through initial calibration of Version 1 of the OWFRM and analysis of the gaging station data, 8 of the 13 stations are considered high priority while the remaining 5 are considered low priority. No definitions of "low" and "high priority;" or the criteria for meeting either designation are provided. These types of decisions and analyses should be discussed with the TWG and agreed upon prior to discontinuing data collection at these gaging stations. NMFS is unable to assess the overall affect to meeting Project objectives without the demonstrated ability of the stations to calibrate the OWFRM.

Conformance with Objective 3

Model status: The OWFRM (Version 2.8) is not adequately developed to assess pre- and post-Project effects. It is also not sufficiently developed to integrate information from other study disciplines [e.g., ice processes (7.6), fluvial geomorphology (6.6)]. Information on calibration, validation and sensitivity analysis are lacking. Clarification in the text is needed to describe the results of the 1D HEC-RAS model used for the flow routing analysis to determine the downstream extent of Project impacts. Initial results presented in the ISR associated with OS-1b confirm that post Project operations will drastically change the flow hydrograph in the Middle River throughout the open water portion of the year resulting in maximum potential stage changes ranging from 9.7 feet near the dam, 5.7 feet near Gold creek, and 2.1 feet near Susitna Station in the Lower River. This amount of stage change is huge in terms of river connectivity and the effects on main channel and lateral habitats. Additionally, the hourly stage effects associated with ramping rates for OS-1b (hydro-peaking) ranged from 0-2.1 feet under dry conditions and 0-8.0 feet under wet conditions near the dam site, 0-4.1 feet near Gold Creek, and 0-4.0 feet near the Sunshine gage in the Lower River. While OS-1b is considered a "worst case" scenario, this illustrates that the ramping rates associated with a hydro-peaking operation will have drastic effects on the water surface elevations throughout the river which will greatly affect habitat conditions, lateral habitat connectivity, river processes (instream flow and riparian), and ice processes (flow under and over existing ice formations).

AEA needs to determine additional operational scenarios that are likely to occur within the system in addition to the OS-1b and newly identified ILF-1 scenario to better understand the overall Project effects throughout the entire Middle and Lower River.

Modification 3-1: NMFS recommends the applicant provide details of what discharges ILF-1 will actually release and examples of ramping rates. NMFS recommends water surface elevations from ILF-1 be modeled with latest version of OWFRM using these discharges.

NMFS needs to understand the discharges associated with ILF-1 if we are to evaluate projects effects. The applicant's consultants also need these discharges to run the models.

Load following was described early on in the study design process as the only operations scenario which would be evaluated. In 2015 the applicant suggested an intermediate alternative ILF-1 but it was not defined.

The study was not conducted as provided for in the approved study plan because insufficient information was provided about scenario to allow the stakeholders to evaluate them.

Modification 3-2: NMFS recommends that additional operational scenarios should be developed and evaluated, including the evaluation of the run-of-river scenario that was required by FERC.

NMFS needs to understand the discharges associated with the scenarios to evaluate Project effects and rank various scenarios based on the energy the alternatives would provide versus the environmental impacts that could result from the proposed project.

The single scenario put forth by the applicant (full load following, OS-1b) does not allow for such "trade-offs "to be evaluated.

The studies were not conducted as provided for in the FERC determination (4/1/2013) because run-of-river was not evaluated.

Modification 3-3: NMFS recommends that HEC-RAS model input and output files be provided to all stakeholders.

This data is needed to conduct an independent verification of conclusions made by AEA regarding the downstream extent of Project impacts as a result of proposed operational flow scenarios.

The USFWS and NMFS's current Memorandum of Agreement with the Alaska Department of Natural Resources and AEA, does not allow for any review of "data analysis" conducted by AEA. AEA reported that there are minimal affects downstream of PRM 29.9 and they do not propose to model the area of tidal influence from the mouth upstream to approximately PRM 10 (Fluvial Geomorphology Modeling below Watana Dam Study 6.6 Technical Memorandum, September 2014). Output files are not "analysis" but products of the model. This minimal effects conclusion is unsupported as the 2014–2015 SIR states that the model for the HEC-RAS model for the middle river is not complete due to a dearth of cross-sections and the fact that it has not been validated. The understanding is that the applicant would conduct scientific studies to illustrate project effects. Open access to methods and products is the standard scientific method.

Since information is being withheld the objective 3 of the instream flow study was not conducted as provided for in the approved study plan.

Modification 3-4: NMFS recommends that the mechanism for integrating operational scenarios with other study disciplines is needed to evaluate the utility of ISF modeling efforts.

This modification will be best implemented through a New Study for Model Integration. A new study request is included as an enclosure.

Objective 4: *Develop site-specific Habitat Suitability Criteria (HSC) and Habitat Suitability Indices (HSI) for various species and life stages of fish for biologically relevant time periods selected in consultation with the TWG. Criteria will include observed physical phenomena that may be a factor in fish preference (e.g., depth, velocity, substrate, embeddedness, proximity to cover, groundwater influence, and turbidity). If study efforts are unable to develop robust site-*

specific data, HSC/HSI will be developed using the best available information and selected in consultation with the TWG.

FERC Study Plan Determination (SPD): Generating the list of parameters for HSC and HSI development: In response to agency requests for a holistic evaluation of the appropriateness of PHASBIM and the ecological relevance of habitat criteria, FERC required the investigation of additional parameters known to influence habitat use by salmonids. FERC's determination (4/1/2013) required AEA to fully evaluate recognized habitat criteria before other means of developing HSC were considered. Resource agencies requested 11 additional microhabitat variables be included in the evaluation. FERC believed that three of those variables (invertebrate drift density, benthic organic matter, and algal biomass) were adequately planned for in the River Productivity (9.8) study. FERC recommended that the following eight additional fish habitat microhabitat variables be assessed: surface flow and groundwater exchange fluxes, dissolved Oxygen (DO) (interstitial gravel and surface water), macronutrients, temperature (interstitial gravel and surface water), pH, dissolved organic carbon, alkalinity, and Chlorophyll-a. FERC agreed with the Services' request for consideration of VHG and substrate permeability, which is necessary to calculate flux.

FERC required that the additional microhabitat variables be assessed to determine if HSC for these variables could contribute to the required analysis of Project effects (section 5.9(b)(5)). On page B-91, FERC determined that AEA should evaluate habitat criteria by "comparison of fish abundance measures with specific microhabitat variable measurements", where sampling overlapped. This was also to include an assessment of vertical hydraulic gradient (see page B-92), in a continuous manner (not merely as a binomial of upwelling or downwelling). If strong relationships were found to exist, further HSC development was then warranted.

FERC required that the three variables (invertebrate drift density, benthic organic matter, and algal biomass) collected in the River Productivity study (9.8) be co-located with FDA (9.5, 9.6) fish sampling to provide a detailed evaluation of fish abundance and these microhabitat variables.

Sample size: FERC stated that the proposed sample size of up to 100 observations of each target species life stage using a stratified random sampling design is consistent with generally accepted practices in the scientific community (section 5.9 (b)(6)), and should provide a robust data set to develop the aquatic habitat models and evaluate Project effects (section 5.9 (b)(5)).

Groundwater: FERC directed AEA to incorporate VHG as a site-specific microhabitat variable by collecting field measurements. Methods were to be developed into the site-specific HSC development process. FERC required that measurements of VHG be summarized in the ISR regardless of whether a feasible or infeasible finding is made. FERC specifically stated that, "Habitat Suitability Criteria (HSC) and a Habitat Suitability Index (HSI) will be developed that include groundwater-related parameters (upwelling/downwelling indexes). This development will follow the general procedures outlined in the Fish and Aquatics Instream Flow Study (8.5) and will include variables specific to groundwater, including turbidity, evidence of upwelling/downwelling, substrate characteristics, and water temperature. Other parameters may also be included. These parameters will be incorporated into the development of HSC type curves that reflect utilization of these variables by fish."

Winter sampling: FERC also directed an evaluation of winter sampling, (April 1, 2014 SPD page B-96), stating that there would be additional opportunities throughout the ILP pre-filling study implementation to evaluate the effectiveness of winter sampling methods and, if found to be effective, implement additional winter sampling efforts throughout the study area.

Methods for Objective 4

Field data for the purpose of developing HSC and HSI were collected within the FAs. The FAs were conceptually representative of a geomorphic reach containing hierarchical habitats and known clusters of utilization. However, the representativeness of these FAs remain unknown, even for the Middle River where the majority of work was conducted.

Proposed Methods: The RSP describes field data collection for site-specific HSC development based on a stratified random sampling approach using the Project's hierarchical classification system and other non-descript attributes. Data collection methods include biotelemetry, foot surveys, snorkeling, and seining. In addition, two other methods, DIDSON sonar and electrofishing, were evaluated for their effectiveness in detecting habitat use in turbid water conditions. Selected methods would vary based on habitat characteristics, season, and species/life history of interest.

The study stated that they would generate preference curves (HSC/HSI) from site specific data for mean velocity, depth, and substrate type for each species, normalize the data and compare results to literature and 1980's curves. Empirical observations of fish habitat were proposed to be used to develop preference curves. For species life stages that did not meet the sample size (n=100), bootstrapping methods would be used to develop curves. To complete the analysis, a group of individual observations (e.g., depth, velocity measurement for a particular species and life stage) will be resampled with replacement up to the number of the original data set.

The study proposed the development of separate, habitat specific, curves based on stream-specific data (i.e., geomorphic reach, mainstem macrohabitat type, clear vs. turbid water, and upwelling areas) with winter versus summer sampling efforts. This would result in four or five separate sets of HSC curves generated for target species and life stages.

Implemented methods: HSC and HSI Development Data Collection 2013-2014. The study performed an investigation of abundance-microhabitat relationships (Evaluation of Relationships between Fish Abundance and Specific Microhabitat Variables Technical Memorandum, 2014). This investigation was part of the Project HSC study efforts, and completed as a requirement of the FERC determination to assess the relevance of the 11 other microhabitat variables of interest to the agencies.

In 2013, a total of 68 selected HSC/HSI sites (50- and 100-meter sampling sites) were sampled within the Middle River FAs to assess habitat use by spawning and freshwater rearing (juvenile resident and anadromous fish) or holding (adult resident fish) life stages of target fish species. In

2014, an additional 72 sites were selected and sampled. The selection process was guided by land access restrictions such that targeted sampling sites were identified based on professional judgment within selected macrohabitat units. This resulted in non-random selection of 129 individual habitat segments representing ten different habitat types within the 7 Middle River FAs: (FA-104 (Whiskers Slough), FA-113 (Oxbow 10), FA-115 (Slough 6A), FA-128 (Slough 8A), FA-138 (Gold Creek), FA-141 (Indian River) and FA-144 (Slough 21) (Table 4.5-4). The distribution of sampling sites between FAs was generally equal with an average of ten sampling reaches selected within each. Additional sampling sites were added from areas outside of the FAs to ensure that highly utilized fish habitats (known spawning locations or areas identified by other study teams) were included in the sampling. The intent of the selected sites was to capture the greatest diversity of microhabitat. Gear-types used to document fish use included foot surveys, underwater snorkeling, single-pass backpack electrofishing, pole/beach seining; and backpack electrofishing with a mobile downstream blocking seine.

Groundwater: VHG measurements were recorded at a minimum of three locations (downstream most, center, and upstream most) within the length of each sampling site in the FAs. There were multiple sampling units within an FA representing different macrohabitats. The VHG device was tested early during the survey period and found to be useful in detecting positive (upwelling) hydraulic gradients. The study reported that the VHG device used was not sensitive enough to distinguish between neutral and negative (downwelling) hydraulic gradients.

Winter sampling (2012-2013): In response to FERC's request for a winter sampling evaluation, AEA provided the 2012–2013 Instream Flow Winter Pilot Studies (Part C, Appendix L) results including proposed methods and sites for the 2013–2014 Instream Flow Winter studies Technical Memorandum. (Review of 2013-2014 Instream Flow Winter Studies Technical Memorandum is included later in this document.)

The 2012–2013 Instream Flow Winter Pilot Studies (Part C, Appendix L) included five or six sites in slough and side-channel habitats of Whiskers Slough and Skull Creek. These sites were used to evaluate the feasibility and effectiveness of studying fish use and habitat conditions during the ice-cover period (Part C, Appendix L: 2012-2013 Instream Flow Winter Pilot Studies). The purpose of the Pilot study was to evaluate the feasibility of different instruments, methods, and approaches for winter data collection to inform a more robust effort during the winter 2013-2014. The Pilot study was to provide preliminary data and information regarding interstitial gravel temperature and water quality conditions; site-specific fish habitat use and behavior; and species richness and size class composition among sampled habitats. Winter 2013-2014 HSC sampling was expanded to open-water areas within FA-104 (Whiskers Slough), FA-128 (Slough 8A) and FA-138 (Gold Creek). A detailed description of results of the 2012-2014 winter studies surveys was provided in the SIR Study 8.5, Appendix A. No new information on winter sampling was provided in SIR Appendix D.

<u>Variances for Objective 4</u>

The study states that methods described in the HSC Development section of the FERC-approved Study Plan (SP) have been implemented, with some exceptions.

- The study did not obtain the approved sample size to develop HSC for target species and life stages. No statistics were provided in the study to ascertain the appropriateness of the bootstrapping procedures used to augment the sample size.
- Spawning redd dimensions were not collected as part of the 2013-2014 HSC spawning surveys. The study concluded that additional redd measurements were not necessary to develop evaluation metrics. Redd dimension measurements were recorded as part of the 2012 HSC surveys to support the spawning and incubation analysis.
- Substrate composition was homogenized to include only two gravel size classes (small and large). FERC stated that two size classifications are consistent with other HSC/HSI curve development studies. We contend that the two size classes of gravel are not representative of the existing substrate. The result may be that the Project will not be able to identify a relationship between substrate composition and fish habitat preference because the substrate classifications used are too coarse. We recommend using the Wentworth grain size scale to characterize the dominant, sub-dominant, and percent dominant substrate size as specified in the approved study plan.
- Water velocity criteria inappropriately truncate the range of depth measurements collected (both shallow and deep). Most fish captures occurred using electrofishing, seining or a combination of the two gear-types which did not allow for the identification of fish focal point position (e.g., nose-to-bed) within the water column. The study stated that the IFS habitat models rely on mean water column velocities so omitting the measurement of focal point velocity will have no adverse impacts on HSC/HSI development and related habitat modeling. However, fish nose-to-bed position in the water column is an indicator of water depth preference for a species and/or life stage. Particularly for those species known to hold hierarchical positions in the water column based on size (age-class), such as Artic Grayling. For preferred nose velocities of target species, it may be necessary to measure higher velocities in the water column to determine whether high nose velocities are unsuitable for the target species (Martinez-Capel et al. 2008). The ISR does not describe Project intentions to calculate nose-to-bed for use in the WUA. We contend mean water velocities are too coarse a measurement and should not be used.
- Exchange fluxes were not reported. Flux is the product of substrate permeability and VHG. There was no measurement of permeability.
- Mesohabitat type was not collected concurrently with fish observational and FDA (9.5, 9.6) data. Instead, mesohabitat mapping was completed as a desktop exercise as part of RSP Characterization and Mapping of Aquatic Habitats (9.9) study. After the mesohabitat mapping is complete, GIS data layers of observed HSC/HSI fish-use will be compared to GIS data layers containing mesohabitat types. Mesohabitat use by individual fish species and life stages will then be assessed. The study states that the variance of using a GIS mapping exercise to determine mesohabitat classifications with observed fish-use will not adversely affect the ability to meet Project objectives. However, error is introduced when using unparalleled approaches to map mesohabitats and observed fish habitat associations. In addition, there are errors associated with (1) mesohabitat classifications provided as part of the FDA study completed by numerous field technicians without consideration of reader error; (2) mesohabitat flow variation; and, (3)

model changes in mesohabitat under variable Project operational scenarios. These error measurements have not been considered.

- Sampling efforts were not as completed as described in the SP. The SP states that River Productivity (9.9) macroinvertebrate sampling will occur at six stations, each with three sites (one mainstem site and two off-channel sites associated with the mainstem site), for a total of 18 sites. River Productivity sampling occurred at five stations on the Susitna River, each station with three to five sites (establishing sites at all macrohabitat types present within the station), for a total of 20 sites. Four stations were located in FAs (FA-184 [Watana Dam], FA-173 [Stephen lake Complex], FA-141 [Indian River], and FA-104 [Whiskers Slough]). Station RP-81 is located in the vicinity of the mouth of Montana Creek. The SP states that the reduction in macroinvertebrate sampling sites will not adversely affect achieving Project objectives because of the greater sample coverage per site. However, only two macroinvertebrate sampling locations are co-located with Middle River juvenile salmon distribution; thereby limiting invertebrate density input data into fish habitat models.
- The FERC determination requested AEA to evaluate which of the recognized microhabitat criteria were relevant to fish habitat selection, and develop HSC models for these criteria. The study did not accomplish this with sufficient statistical rigor. The study used univariate HSC curve exploration to identify what criteria would be used in their multivariate HSC models. There are fundamental statistical problems with multivariate HSC models developed from univariate HSCs that are not acceptable for determining Project effects and limit the usefulness of the collected existing data.

AEA did commission a separate analysis to investigate relationships between abundance and microhabitat parameters, based on FERC's determination to identify criteria worthy of examination and consideration for HSC modeling. This investigation was summarized in the 2014 Technical Memorandum[2]. The Technical Memorandum stated that "the HSC Study is more relevant for studying fish habitat preference than other data collection efforts. Because it is clear from the FERC recommendation that FERC agrees with this characterization, habitat data collected as part of the HSC study will be considered primary." The Technical Memorandum went on to read, "the overall objective of the analysis was to provide a comparison of fish abundance measures with additional microhabitat variables where sampling efforts overlap spatially and temporally." This approach does not allow for meaningful comparisons. In fact, the Technical Memorandum stated "there are no surface flow and groundwater exchange flux data available and so no analysis of this variable has been completed."

The opportunistic approach utilized by the study was too spatially and temporally irrelevant and non-scientific. First, habitat measurements need to be collected only when fish are spawning or rearing, not during other periods when local microhabitat is irrelevant to occupancy. The study is not clear whether microhabitat criteria surveys were conducted during, after, or before surveyed locations were occupied. Second, these measurements need to be collected within and outside the

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[2] Susitna-Watana Hydroelectric Project (FERC No. 14241), Fish and Aquatics Instream Flow Study, September 2014. Evaluation of Relationships between Fish Abundance and Specific Microhabitat Variables, Technical Memorandum. Prepared by R2 Resource Consultants, Inc.

distribution of spawning and rearing (e.g., unoccupied/unused locations). Using transect locations within the distribution of fish to represent unused habitats prevented the study from considering the availability of habitat outside the distribution of fish. This does not allow the study to assess biological relevance, which would require comparison of the statistical distribution of microhabitats within and outside the spatial distributions of fish. Third, because habitat is hierarchical, the sampling effort should have been stratified by meso and macrohabitats on the longitudinal distribution of the floodplain. The study sampling design did not meet these criteria. Instead, it appears that the study modeled the variability of surface hydraulics, over time (instead of space), and also at the expense of forfeiting any comparison of groundwater exchange.

The study also had inconsistencies with surveyed abundance and microhabitat data. According to the study, there were no adult salmon abundance data, microhabitat data were not integral to the collection of the abundance data, and groundwater data were incomparable. If the microhabitat data were not relevant to the abundance data, the influence of VHG could not be considered, and if adult data were not available, then the 2014 investigation of abundance-microhabitat relationships was irrelevant to the overall effort. The study concluded the results are more appropriate for identifying relevant habitat criteria. We conclude that the abundance and habitat data was not sufficient for accomplishing study objectives.

Conformance with Objective 4

HSC habitat utilization surveys in the study were not based on the proposed stratified-random sampling, structured by the Projects hierarchical habitat model. The study surveys were reported to be random, but the incorporation of randomness is questionable. The study noted that surveys focused on clusters of known spawning. If randomness was incorporated within these clusters, it was not mentioned. Because measurements of microhabitat were made directly in association with occupied sites, the surveys were likely not random. In clusters, surveys were supposed to be stratified according to the Project's hierarchical habitat model and the distribution of fish to control for the influences of habitat and discern the ecological relevance of microhabitats under investigation.

The influence of microhabitat is manifested in the context of meso and macro habitats. For example, turbidity, groundwater exchange, and cover affect the role of surface-water hydraulics in habitat selection. The influence of macrohabitat, in the form of channel complexity and regional groundwater exchange influence local population fragmentation through spatial segregation of spawning tactics (see Leman 1993; Mouw et al. 2014). The study did not stratify surveys of microhabitat criteria in regard to the hierarchy of macro or mesohabitat present on the Susitna River. Because the biological relevance of flow hydraulics, VHG, substrate, and other criteria differ amongst the various habitats of the floodplain hierarchy, the study could not draw valid conclusions about flow-habitat relationships.

Microhabitat surveys were not structured with regard to the distribution of fish, which is likely contiguous or highly clumped in space. The most effective way to survey and assess microhabitat relevance to habitat selection is by structuring surveys to account for the distribution of fish. Habitat must be clearly surveyed within and outside the longitudinal distribution of fish to discern ecological relevance. Random surveys of available habitat, at the same longitudinal floodplain position resulted in data that could not control for VHG, and therefore could not address whether the statistical distributions of microhabitat criteria differed outside the distribution of fish. Therefore, the study cannot make any valid conclusions about the influence of flow hydraulics, substrate, and cover.

The overarching questions directing the HSC study were where and why fish select habitat. The survey design used in the study only allowed a characterization of microhabitat utilization where fish were most common, in terms of spatial coordinates and microhabitat associations. We essentially have been presented with the distributions of microhabitat utilization, within clusters of utilization, with no means of sorting through which associations are relevant. Unless relevant habitat criteria are isolated, environmental Project-effects cannot be assessed. Strategic surveys are required to isolate ecological relevance. The study surveys were not strategic because they did not account for the distribution of fish and habitat.

Regarding the distribution of fish, surveys of microhabitat within and outside the distribution of spawning or rearing habitats are needed to identify ecologically relevant criteria. This must be done on the longitudinal floodplain dimension, not just the lateral dimension. Habitat surveys stratified by macro- and meso- scales are required to strategically assess relevance in a valid (statistical, ecological, evolutionary) context. This stratification should have been performed on both the lateral (main-channel to upland) and longitudinal (riffle-pool sequence) dimensions.

Groundwater: The study measured VHG in a very limited context, and did not quantify flux. More importantly, surveys of habitat utilization and availability were not structured with regard to groundwater exchange. Groundwater exchange is known to be a primary driver of habitat selection (particularly in Alaska). VHG is typically viewed as a binary variable, though the gradient is continuous. As such, it should be the primary basis for structuring studies of the distribution of fish and continuous microhabitat variables. The study did not do consider VHG as a primary driver, and therefore was unable to isolate and discern the relevance of flow hydraulics and other microhabitat criteria on the distribution of fish.

At a micro scale, bedform topography interacts with flowing water to induce localized circulation of river water through the bed of the river, regardless of the regional VHG. This can be assessed by installing mini-piezometers at bedforms where spawning occurs. At intermediate spatial scales, channel complexity drives the exchange of river water through bars, causing localized upwelling and downwelling in isolated reaches of primary and secondary river channels. This is also independent of the regional VHG. Installation of piezometers along the longitudinal dimension of the secondary channel network may have revealed localized reaches of upwelling. At the regional scale, constrictions in the fluvial aquifer drive upwelling throughout the channel network, but most importantly in the main channel. This can be assessed by installing mini-piezometers on the shoreline of the main channel. The prevalence of downwelling in the main channel will not prevent upwelling in the secondary channel network; quite the opposite is typically found.

The study did survey the availability of upwelling and downwelling (VHG), but it was not measured in association with habitat utilization. Consequently, VHG was not assessed at the local level. Measurement of VHG in the study was also limited to 3 shoreline measurements at each survey unit. There is no evidence that the study considered VHG, laterally, within the channel matrix of their survey units. Because the study did not approach their assessment of VHG hierarchically, there is no way to assess the influence of VHG, with respect to habitat utilization. Salmonids with differing spawning periodicity have been observed spawning in association with different ground and surface water configurations. Fall populations typically spawn in association with localized downwelling, in regions of upwelling (Baxter and Hauer, 1999; ADFG, 2005). Summer populations typically spawn in association with localized upwelling in regions of downwelling (Leman 1993, Mouw et al. 2014). These different spawning tactics are manifested in the context of very different macro, meso, and microhabitat associations. The study design did not assess the relative roles of hierarchical exchanges in ground and surface water in structuring the distribution of spawning and rearing. As with the other habitat criteria, VHG was not assessed in the context of the Project's hierarchical habitat model.

Limited Habitat Utilization Criteria: Understanding the habitat variables that influence fish habitat selection is more important than developing the best fit from variables that may not be ecologically relevant. The study did not perform a statistical analysis of ecological relevance for any criterion investigated. Utilization curves demonstrate associations with statistical distributions of microhabitats when the same microhabitats are compared outside the distributions of species and life stages under investigation. Statistical comparisons are an integral step of ecological investigation.

The study did construct univariate models for certain microhabitats, but did not examine the relevance of these to fish habitat selection. In addition, the importance of other habitat criteria was not determined. The study reported Akaike Information Criterion (AIC) values for each of the univariate models, but this only determines the relative (not absolute) significance of each model. Therefore, NMFS cannot determine whether the models were equally good or poor.

The study stated some limitations and assumptions about the surveys of habitat criteria. Methods for collecting fish observational data and microhabitat variables metrics have limitations and assumptions that should be explicitly identified prior to integration into habitat-specific models. For example, the study stated that spawning chum salmon do not show a preference for groundwater upwelling in habitats in water depths greater than two feet. The study is unclear if: (1) spawning areas in surface water greater than 2-feet deep were assessed; or (2) VHG was measured in water greater than 2-feet deep. There are no data supporting the conclusion that depth precludes upwelling or redd site selection. The study stated, "there is some possibility that this interaction is an artifact of the difficulty in sampling VHG in deeper water. This issue will be investigated further prior to the Updated Study Report." To date, the study still has not performed these additional investigations. Instead, examination of VHG is left out of the results.

Other limitations of the HSC/HSI criteria univariate modeling include the following:

- Results presented for chum salmon spawning were limited to clearwater habitats (NTU<30). The study should account for the propensity of chum salmon spawning in turbid waters.

- Turbidity was determined to be a strong predictor of Coho Salmon fry habitat preference with limited fry data from turbid environments. The study did not present how this "preference" was identified, in the absence of any statistical analysis, and how the relationship between HSC and turbidity was determined.
- VHG, temperature, dissolved oxygen (DO), specific conductivity and turbidity were measured in only three locations per 50 meter of reach length in the FAs. Three measurements per 50 meter of reach length is likely inadequate as those measures at meso- and microhabitat levels are heterogenous at that scale. This may not be a valid assumption for some variables (e.g., DO, temperature, specific conductivity) but should be tested prior to reducing sampling efforts.
- Within In the FAs, VHG is assumed to be either upwelling or not, which could be negative or neutral. The study reported that less than 6% of sampled locations measured negative (downwelling) VHG. Surface-groundwater exchange is pronounced and highly variable in the Susitna River making it unlikely that only 6% of FAs are downwelling. This strongly suggests that the surveyed locations were not representative of utilized habitats, particularly for salmon. Downwelling is also important to macroinvertebrate productivity and species life history stages.
- Water temperature, DO, and specific conductivity was not reported to be important for chum salmon spawning site selection, but all data were pooled, regardless of macrohabitat, so this conclusion is tenuous without the hierarchical habitat model. Water temperature should be evaluated more robustly and under alternate operational scenarios.
- Criteria were not evaluated on the basis of macrohabitat, according to the RSP.
- Criteria were not evaluated with the target sample sizes specified in the FERC determination.

The study used the results of the univariate model to select input variables to the multivariate model. The study's use of univariate habitat associations to identify which criteria to use in their multivariate models is invalid. Univariate utilization functions cannot be used demonstrate ecological relevance.

Multivariate Model (of Fish Habitat Suitability): Proposed Project operational scenarios will result in conditions that are outside those of the natural system. The ISR states, "Note that these models are not displayed beyond the conditions under which spawning was observed (spawning observed at depths between 0.20 - 3.3 feet and velocities up to 2.2 ft/sec). Suitability criteria beyond these conditions have not yet been determined and cannot be determined using statistical methods." The preliminary multivariate model for chum salmon, for example, does not represent conditions beyond the observed conditions (0.20 – 3.3 feet and velocities up to 2.2 ft/s). The coho salmon fry (ISR Appendix M, pages 9-12) initial curve development is limited by data collection restricted to the open water period, at depths less than 3 feet, with lower turbidity levels.

Curve development should be based on conditions beyond those observed in the natural system. For example, tails of the graph representing the curves should approach zero at either end.

Models must include values that are outside of baseline conditions in order to have predictive capabilities for anticipated Project effects.

Additionally, the model substrate inputs are limited to cobble or gravel-dominated substrate and do not consider the full spectrum of substrate heterogeneity. Therefore, the model cannot account for conditions beyond those observed; it does not include all conditions that were observable.

Macrohabitat Specific Criteria (post-Project conditions): The ISR discussion of multivariate models notes that all macrohabitats exhibited variability. Based on that result, macrohabitat type in the HSC modeling efforts should have been considered. The study stated “Macrohabitat type has not been included [in HSC modeling], although differences in habitat preference among macrohabitat types are possible” (AEA 2014 Appendix M). AEA considered it prohibitive to account for macrohabitats within the realm of HSC modeling because replication of observations at each habitat type is needed for this purpose. The study assumes that post-Project macrohabitat relationships would be static, so this justifies the lack of development of macrohabitat specific criteria. This same rationale is applied to other HSC variables, such as temperature and turbidity, modeling the pre-Project conditions, but not the range of post-Project conditions. Unless the study examines the relevance of macrohabitat criteria on the basis of their hierarchical habitat model, it will be impossible to evaluate flow-habitat relationships for this project. During the 1980s, there were separate curve sets developed for main and off channel sites, given the extreme differences in habitat characteristics and patterns in habitat utilization among these diverse habitats.

The following are identified limitations on the HSC/HSI criteria multivariate model inputs that should be addressed to conform to Objective 4:

- Water depth - initial results show that a 1.5 foot depth is preferred among Coho Salmon fry. The study provides no analysis or discussion of data collection efforts and therefore we do not know if measurements were taken at depths beyond the 1.5 foot depth.
- Velocity - The ISR reports that velocity has a relatively low influence on habitat utilization, especially when cover is present, yet velocity is used in many models without reporting its significance.
- Turbidity - an inverse relationship between fish habitat preference and turbidity is indicated. The ISR also noted that habitat cover is less important in turbid waters. Cover and turbidity were combined into a 3-level cover factor consisting of (1) no cover in turbid water (lowest preference); (2) cover in clear water (highest preference); and the combined category of (3) cover in turbid water or no cover in clear water (moderate preference).
- Groundwater downwelling - The Services requested that downwelling be included in the assessment of microhabitat variables for HSC development. The Project combined downwelling with neutral gradient masking any potential relationship to fish habitat preference related to downwelling. Given the importance of ground water exchange to salmon, this approach does not provide sufficient resolution, especially when neutral gradients are avoided by spawning salmon (Leman 1993; Mull et al. 2007).

- Surface water temperature – A strong relationship between decreased habitat use and increasing water temperature was observed. However, the ISR states that based on the observed range of water temperatures the study could not determine the importance of temperature and may exclude water temperature from future modeling efforts. Sufficient water temperature data collection should be able to determine the significance to habitat selection. Data collection efforts were limited due to small sample sizes; and the analysis combines all species, life stages, and macrohabitat samples for comparison. Stakeholders went to great length with AEA to develop a relevant hierarchical habitat model and species periodicity tables to account for the variability in the Susitna River habitat. The study must survey and analyze data accordingly, not pool all data together and draw conclusions from insufficient data collection.
- DO –An inverse relationship between DO and juvenile coho salmon presence was indicated with Project data. The study concluded that this relationship did not make ecological sense, but we suggest that this relationship is biologically valid. Coho salmon fry may utilize low DO habitats to avoid competition and predation from species that are less tolerant to those conditions (e.g. Chinook salmon, rainbow trout, Dolly varden). This relationship should be tested during winter as well.
- Specific conductivity—no relationship between habitat utilization and specific water conductivity was identified. As with all other microhabitat criteria, no diagnostics were reported to support the exclusion of this variable.

Winter Sampling: The ISR presents findings from the 2012-2013 Instream Flow Winter Pilot Studies (Part C- Appendix L). The pilot study tested the proposed approach for monitoring water quality and water stage conditions at salmon spawning locations while recording fish habitat use. The study objective was to develop winter criteria by species-lifestage and macrohabitat. A review of 2012-2013 Instream Flow Winter Pilot Studies (Part C- Appendix L is provided in Appendix 1. The 2012-2013 pilot study was a pre-cursor to the 2013-2014 Instream Flow Winter Studies. No new information was presented on the examination of winter criteria or development of winter HSC in ISR Part D, Appendix D. Separate HSC are not proposed by AEA for winter, instead the same curves are proposed for all seasons and all habitats.

2013-2014 Instream Flow Winter Studies Technical Memorandum: The Instream Flow Winter Studies Technical Memorandum was released September 17, 2014. The objective of the winter study was to evaluate potential relationships between mainstem Susitna River stage and the quality and quantity of winter aquatic habitats that support embryonic, juvenile, and adult life stages of fish species. For the most part, existing conditions are described, but the Technical Memorandum lacks a description of post-Project conditions under proposed operational scenarios. The study background indicates that winter streamflow is fed primarily by groundwater and consequently discharge is stable. This is true for the current winter conditions, but post-Project conditions will be drastically altered due to increased winter flows and intra-daily pulse-flow fluctuations. Post-Project conditions need to be studied. For example, HSC/HSI curves for fish species have not been developed to describe the response of fish to relatively short-term flow fluctuations (i.e., ramping), especially during winter conditions.

The FAs were selected for the 2013-2014 ISF winter study because they contain a diversity of habitat types with groundwater influence. The Services requested that habitats used by fish, as well as habitats not used by fish, be studied for purposes of developing HSC/HSI criteria. Therefore, selected winter study sites should include both used and unused sites. To assess whether groundwater is influential to fish habitat site selection we need to understand whether fish are using winter habitats that both do and do not have groundwater influence.

Breaching flows: The study suggested that higher flows in the winter time will result in periodic or continuous inundation of habitat areas that are normally dewatered and/or disconnected from the main channel. In addition, higher flows will subject lateral habitats (side channels and side sloughs) that under existing conditions are fed mostly by clear, stable and comparatively warm groundwater flow to daily/hourly flow increases from the much colder Susitna River. The frequency and magnitude of these flows into these habitats will depend on the specific breaching conditions of each habitat feature. The breaching conditions are exactly what we are trying to assess under post-Project conditions. Open-water and under ice two dimensional hydraulic models are not yet fully developed making post-Project assessment tenuous. Higher Susitna River discharge during winter may increase the frequency and magnitude of side channel and side sloughs breaching by cold main channel streamflow, and higher stage may alter the extent of groundwater upwelling in side channel and off-channel areas. In addition, the daily fluctuation in Susitna River flow may affect conditions in areas of salmon egg incubation that may result in periodic redd dewatering as well as changes in temperature (i.e., prolonged egg incubation, potential freezing during dewatered periods).

The following observations are for Pre-Project conditions.

The Technical Memorandum states that effects of Project operations on salmon spawning areas, such as redd dewatering, freezing, channel inlet breaching, scour, and interstitial gravel water quality (temperature and DO) will be evaluated as part of the effective spawning area analysis. There is no timeline provided for the completion of this evaluation.

The Technical Memorandum states that main channel Susitna River interstitial gravel water temperatures appear to be strongly influenced by surface water at continuous monitoring sites with temperatures remaining near 0 degrees for much of the measurement period. Among continuous monitoring sites in side slough and upland slough habitats, interstitial gravel temperatures were typically warm relative to main channel conditions (2-4 degrees C), which may represent strong influence of groundwater in these habitats. Currently there is no way to model how these conditions and relationships will change under post-Project operations.

The variation in interstitial gravel temperature response to main channel breaching of Slough 11 between sites 138-SL 11-04, 138-SL 11-06 and 138-SL 11-2 may be an indication of the localized influence of groundwater and/or that multiple sources of groundwater may be present within a given habitat. This is a key implication for groundwater studies and model validation.

The ISR notes that temperature measurements within groundwater wells were warmer and conductivity values intermediate to other mainstem sites. Exceptions to this general trend were at side channel Site 104-SL3B-10, which exhibited specific conductance and water temperatures unlike other side channel sites, and side slough Site 104-CFSL-10 where specific conductance was more similar to mainstem habitats than other side slough habitats (Figure 12). We recommend further study to assess why this Site may not be following the trends found at other sites.

<u>Post-Project Conditions Still Need to be Considered</u>

Salmonid Egg Incubation and Winter Survival: The percent winter mortality due to the dewatering of eggs in redds in the Susitna River would likely vary widely depending on the strength of groundwater influence at the different redd locations. The Susitna River studies conducted in the 1980s indicate that groundwater upwelling was the principal factor affecting salmon egg development and survival in the Middle Susitna River. This highlights the importance of understanding groundwater processes and being able to predict post-Project effects on those processes in the Middle River. This also highlights the importance of groundwater and breaching flows which will be greatly affected by the post-Project increases in winter flow conditions under hydro-peaking fluctuations.

Stranding and Trapping: Emergent salmon fry are sensitive to environmental conditions, including fluctuations in river stage. Rapid recession of river stage can result in fry stranded on the bed substrate. Previous studies of salmon stranding occurrence relative to stage fluctuations determined that stranding was size selective among salmon fry and individuals less than approximately 50 mm in length were particularly susceptible (Bauersfeld 1977, Bauersfeld 1978, R.W. Beck and Associates 1989, Olsen 1990). The study has not yet addressed stranding and trapping and the importance of being able to model rapid and perpetual flow fluctuations in side channels and side sloughs under Project-proposed winter flow fluctuations.

Winter habitat conditions for juvenile and adult fish: Winter habitats are often used repeatedly from year to year by fish species, which may indicate that stable environments are critical during the winter period (Reynolds 1997). The need to provide spatial and temporal habitat persistence for holding/over wintering for all species has not yet been addressed.

Due to the study variances, limitations, and the failure to address post-Project conditions, we find that the current effort is not in conformance with the study objectives and plan. We are concerned that habitat variables have not been adequately assessed to determine the significance to fish distribution. The purpose of the Evaluation of Relationships between Fish Abundance and Specific Microhabitat Variables Technical Memorandum (September 17, 2014) was to address Objective 4 in further detail, however our review of the methodologies and statistical analysis presented in the Technical Memorandum concludes that AEA has not sufficiently abated resource agencies concerns or met FERC's SPD.

Continuing concerns include: (1) the limited microhabitat variables being assessed by the Project, (2) the biased nature of microhabitat criteria selection, (3) the scale at which microhabitat criteria are being assessed, (4) the ability of the Project to model the variables pre- and post-Project, and (5) the ability to integrate the relevant variables into synthetic evaluation of alternatives and DSS. We recommend no further work be conducted until a new study is developed to address these concerns.

Because of incomplete sampling across FAs and inconsistent sampling efforts within individual FAs, additional studies are needed to better understand current fish populations and habitat requirements for over-wintering fish stocks including any groundwater influence in winter habitat areas under current conditions in the Susitna river watershed. In addition, modeling efforts to quantify and describe current water quality conditions, groundwater flow, and fish communities within the Susitna River watershed are not sufficiently described to assess the amount of uncertainty included in model outputs.

Statistical Analyses of Criteria and Development of HSC Models: There were two primary statistical concerns with the HSC study. One concern is the description of methods and the description of the logic underpinning the study. Although the description of the methods is distributed over multiple reports covering hundreds of pages, the methods descriptions are still incomplete. We could not find one place with a clear, technically sound, and complete description of the methods for the habitat suitability curves. To achieve standards for scientific reporting, the study should describe the following:

- A complete description of each variable in the regression equation and how it was derived,
- A complete description of the method used to estimate the parameters (e.g., ordinarily least squares vs. generalized linear model using likelihood),
- Complete model equations (separate from reporting on model parameters), and
- All information necessary to understand the methods in sufficient detail to repeat the analysis.

The second statistical concern relates to reporting the results, which were incomplete and not consistent with the approved study plan. Fish and Aquatics Instream Flow Study (8.5), 2014-2015 Study Implementation Report, Appendix D reports on a large number of curves developed for the purposes of habitat suitability estimation. Although this report contains a considerable amount of information, it does not contain adequate information to review the quality of the estimated curves, the adequacy of the model fit to the data, and the validity of the model for use in predicting flow-habitat relationships.

The equations, such as the examples found in Appendix D, seem to be the only presentation of the numerical results of the regression analysis, and this presentation is incomplete. The accompanying statistical information centered on the AIC value and information on multi-colinearity. However, other important material to judge the statistical significance of the overall model that was not described in the study includes: the statistical significance of the model parameters, the overall quality of the model fit, and information on model validation (Zuur et al. 2009). There was also no reported sampling error (e.g., confidence intervals or standard errors) for the individual parameter estimates. The evaluation of the HSC models without this basic statistical information is not possible.

We have significant concerns about the little information we have regarding model development. The data analysis in the study combined utilization data, regardless of the habitat context, and modeled the probability of utilization in the context of availability data collected in a different dimension and habitat context. This method of data analysis can only operate on the assumption that associations with local microhabitat are spatially invariant. In other words, the association between utilization and any microhabitat variable is assumed to be the same, regardless of the habitat context (e.g. main channel or side slough). This assumption is counterintuitive and does not adhere to the scientific literature guidance the study has cited (e.g. Leman 1993; Mouw et al. 2014).

The study does not contain basic descriptive statistics of the range or variability of parameter values, globally or on a macrohabitat basis. How did the ranges and variability of occupied parameter values differ amongst habitats? How did the ranges and variability of occupied parameter values differ from unoccupied parameter values, outside the distributions of fish? Without statistical rigor, the study results are impossible to evaluate and, currently, the study is fatally flawed. In some cases, AEA may have the data to address these questions, but it is clear that some of these, most notably whether or not the statistical distributions of occupied microhabitat parameter values differed from those outside the spatial distributions of utilization, cannot be answered by the study. The study did not develop a survey design that would produce statistically valid results for any species or life stage.

In addition, basic exploratory data analyses were not performed to isolate which habitat criteria were ecologically relevant. AEA used univariate HSC curve exploration to identify what criteria would be used in their multivariate HSC models. Of all the issues with the data analysis, this is the most problematic. Associations with criteria are only relevant to habitat selection if the statistical distributions of occupied microhabitat differed from that of unoccupied habitat, outside the local (spatial) distributions of species and life stages under investigation.

<u>The Use of Logistic Regression</u>

The study used logistic regression to model probabilities of utilization, based on incomparable data, with incomplete model diagnosis. The AIC criterion, the diagnostic tool the study provided, is a measure of relative quality and cannot be used to distinguish the effectiveness of a set of models. The study apparently used logistic regression to test hypotheses about the biological relevance of the various HSC and the role in structuring the distribution of fish spawning and rearing. However, the study models primarily used water depth and velocity, because these variables were the output of the hydraulic habitat modeling. There was no diagnostic evaluation of the models or the model parameters (e.g., microhabitat criteria).

The AIC can be valuable when assessing the relative quality of statistical models, once the model is verified. Without model verification, the AIC tells nothing of the quality of the model and cannot be used to test hypotheses set, a priori, or as a result of model execution. For example, if all candidate models fit poorly, the AIC will not differentiate any relative quality. The study needed to demonstrate the absolute quality of the proposed models using more appropriate diagnostics. Were the models significant? Did the models fit the data well? What was the classification success? The AIC statistic does little to address these questions. The AIC assesses the relative quality of significant, good fitting models achieving high classification success. Once a subset of quality models has been selected, the AIC is a good way to achieve the best of the best and the most parsimonious of models. Because the study models include as many as seven model parameters and three or four microhabitat variables, the reported AIC values provide little to no assistance in model evaluation.

The study would have benefitted from a more appropriate and strategic use of logistic regression. Conventionally, logistic regression is utilized to model the probability of a response on the basis of some influential factor (https://en.wikipedia.org/wiki/Logistic_regression). An analogy would be to model the probability of passing a test (dependent variable) as a function of time spent studying (independent variable). According to logistic regression, the researcher would stratify and query students on the time they spent studying. By only surveying occupied habitat, Study 8.5 did the equivalent of surveying students who passed, failing to structure the study around the time spent studying, and the probability of passing the test based on study time. Study 8.5 did the equivalent of surveying passing students instead of the variable of time spent studying and failing to perform a valid survey of those students who did not pass. Using VHG as a specific example, the study could have surveyed sites with a positive and negative VHG, in order to assess the role of VHG in structuring habitat selection. Instead, the study surveyed only occupied sites and measured VHG. Then, at the same VHG, the study surveyed unoccupied sites in a different dimension and within incomparable habitat types. The study should have surveyed VHG at occupied sites and then moved up or downstream to unoccupied locations in the same habitat stratum (e.g. a side slough riffle) and measured VHG. With replication of such valid comparisons of like habitat within and outside the distribution of fish, the relevance of VHG would emerge.

The study would benefit from a better strategic use of logistic regression. Logistic regression is a better tool for testing hypotheses about specific microhabitats than it is for generating them. For example, if the statistical distributions of velocity significantly differed within and outside the distributions of spawning and rearing, can logistic regression be used to successfully predict occupancy on the basis of flow velocity? The study skipped the necessary step of demonstrating ecological relevance, prior to modeling habitat relationships. Instead, the study used the univariate curve generation process to sort through the various microhabitats used in the multivariate process of curve generation.

The study does not adequately describe the random effects and constants in the modeling effort. The significance of the additional factors inserted into the modeling effort, to account for site selection and longitudinal effects, was not reported. The significance of these factors should be reported, compared, and evaluated in context with the other parameters in the model.

The study stated, “The candidate models included polynomial effects when non-linear relationships were reasonable ecological hypotheses.” If the experimental design resulted in data that could have been analyzed in the context of a hierarchical habitat model, ecological interpretation would have been reasonable. Instead, the study pooled all data from every habitat context that was surveyed, making ecological interpretation impossible.

The results of the models predicted ranges of probabilities as low as 0 to 0.20. These ranges in probability make the relevance of the models questionable. Low predicted probabilities of utilization may or may not be reflective of model quality depending upon sample size, but the effectiveness of predicting future conditions during proposed project operation is questionable.

The ranges in predicted probability did surpass 0.9, but this was achieved at the expense of controlling for other variables. The necessity to control for other variables in the multivariate models is expected because data was pooled from all habitats. The necessity to control for certain habitat criteria brings the realism of the models into question. How useful is this model for predicting future conditions?

The study resulted in models predicting the probability of habitat suitability for sets of highly narrow conditions. For example, the chum salmon curve predicts the probability of spawning for a given substratum and a fixed depth of 1.2 feet. If the study controlled for VHG (lurking variables), and stratified the data analysis based on their hierarchical habitat model, the results would have demonstrated the relevance (or irrelevance) of the variables explored. The necessity to build models at fixed conditions is likely a product of pooling data from a wide range of habitat types with a wide combined range of all microhabitat variables involved. This pooled set of conditions is being forced to represent variable patterns of utilization that are known to significantly change indifferent habitats and during all seasons. The study presents HSC models as representative of all conditions and all seasons. This does not make ecological sense.

The strong physical contrasts among the various habitats within the hierarchical model have been demonstrated to promote population diversification, with populations segregated into diverse life history tactics. These populations interact with physical habitat in very different ways within and among species. For example, by pooling all the chum salmon spawning data, the study considered at least two different spawning tactics, adapted to radically different habitats, amongst these radical differences, as a single response unit.

Modification 4-1: NMFS recommends that habitat criteria must be surveyed with regard to the Project's hierarchical habitat model, according to the approved study plan.

The statistical distributions of microhabitat among the various macrohabitats differ drastically. Surface water dominated habitats are typically turbid (in summer), turbulent, and have finer-grained substrates. Groundwater dominated habitats are generally clear, tranquil, and are characterized by coarser substrates. Fish use of these criteria in these different macrohabitats varies. Unless habitat criteria are examined according to the Project's hierarchical habitat model, differences in utilization cannot be considered, habitat-specific criteria cannot be evaluated, and habitat-specific responses cannot be identified.

The study was not conducted as provided for in the approved study plan.

Modification 4-2: NMFS recommends that the HSC must be analyzed according to the Projects hierarchical habitat model and HSC must be developed for individual macrohabitats. During the 1980s studies separate HSC models were developed for main and off-channel habitats, due to the gross differences in habitat and fish utilization represented within these surface and groundwater dominated environments. The study made no attempt to develop separate HSC models for these different macrohabitats. Only when the criteria are surveyed and analyzed in the context of the approved hierarchical habitat model will the study be able to address the approved study plan and consider the ecological relevance of the habitat criteria determined by FERC as necessary for investigation.

The study was not conducted as provided for in the approved study plan.

Modification 4-3: NMFS recommends that habitat criteria must be surveyed with respect to the distribution and periodicity of fish species and life stages present in the river.

Habitat utilization and availability were universally surveyed within the distributions of fish that the study called clusters of known utilization. To identify which microhabitat criteria were ecologically relevant, the statistical distributions of utilized criteria must be compared to the statistical distribution of these criteria outside the local distributions of fish species and life stages. In other words, microhabitats must be surveyed in locations occupied by fish and in locations unoccupied by fish. Surveys of microhabitat outside the localized distributions of fish will provide AEA the ability to make valid comparisons with occupied microhabitat and analyze ecological relevance in a sound statistical and ecological manner.

Modification 4-4: NMFS recommends surveys of available unoccupied habitat should be conducted in habitats similar to those occupied in order for ecologically and statistically valid comparisons to be made.

As executed, AEA surveyed availability in the wrong dimension (lateral instead of longitudinal) and in different habitat types, from those utilized. This was ecologically and statistically invalid. Availability could only have been assessed in unoccupied habitats within the same habitat stratum (e.g. unoccupied side slough riffles as compared to those occupied), in order to be valid. This failure was a product of the disregard for the approved hierarchical habitat model that was to be used to structure data collection and analyses.

Modification 4-5: NMFS recommends that the HSC study experimental design compare the dependence of fish habitat selection on VHG. This can only be accomplished by surveying habitats with a different VHG.

The study demonstrated a misunderstanding of ground and surface water interactions on alluvial floodplains. Both utilized and available habitats were located within the same longitudinal positions and would have been characterized by the same regional VHG. Furthermore, the study did not assess VHG locally, in association with spawning or rearing, and did not assess VHG hierarchically, according to the Project's hierarchical habitat model. Ground and surface water exchanges occur locally, in association with channel bedforms, at intermediate scales between main and side channels (and sloughs), and regionally at the floodplain scale. Exchanges operating at each of these scales are known to influence the distribution of spawning.

Modification 4-6: NMFS recommends that AEA analyze their data in accordance with their proposed and approved hierarchical habitat model.

The study pooled all data from all habitats throughout the river to analyze habitat criteria and develop HSC. Pooling forfeits examination of habitat relationships within different habitat types where different life-history tactics are known to exist. Pooling effectively caused the study to abandon the hierarchical habitat model developed for this project. The pooling of the data was invalid from a statistical, ecological, and evolutionary perspective.

Modification 4-7: NMFS recommends that AEA must evaluate microhabitat criteria by comparison and examination of relationships between abundance and microhabitat criteria. The study must evaluate the statistical and ecological relevance of these relationships using statistical methods.

Through the use of statistical methods, the study should identify which criteria are ecologically relevant to fish habitat selection and use this subset of relevant criteria to develop HSC models (with logistic regression or otherwise). The study used a univariate utilization curve generation process to select habitat criteria for use in multivariate modeling. This is an invalid way to select criteria.

Utilization does not equate to ecological relevance. Utilization will associate with any number of existing microhabitat criteria and often can simply reflect the distribution of a given criterion, irrespective of the relevance to habitat selection. Identification of relevance requires examination of microhabitat availability outside the local distributions of species and life stages. Relevance can be found only when utilized criteria differ from what is truly available, in a statistically significant way. There are a number of basic exploratory statistical methods that can be used to evaluate the significance of differences between the statistical distributions of occupied and unoccupied microhabitat. The nature of the data will determine which basic method to use, through reference of any basic statistics text.

The selection of criteria for HSC model development prevented a statistically valid examination of criteria and examination of interactions between criteria. The selected criteria for multivariate modeling that were necessary for implementation of a hydraulic habitat evaluation, regardless of whether or not these criteria were ecologically relevant to habitat selection.

Modification 4-8: NMFS recommends developing a study plan for macrohabitat specific utilization models (HSC/HSI) for open and ice covered periods for fish species and life-stages. The study modification should be designed to address resource agencies concerns about the assessment of relevant microhabitat variables and their influence on fish habitat site selection. This study modification will address FERC's statement in the SPD for the need to develop "a detailed evaluation of the comparison of fish abundance measures (e.g., number of individuals by species and age class) with specific microhabitat variable measurements, to determine whether a relationship between specific microhabitat variable and fish abundance is evident." FERC also stated that if there is evidence of strong relationships between the microhabitat variables and fish abundance for a target species and life stage, then sampling should be expanded in future study.

Modification 4-9: NMFS recommends increasing replicates of macrohabitat observations for winter studies to be consistent with resource agencies request during the study plan development. Specifically, resource agencies request that winter sampling for juvenile salmon occur at a minimum of six replicate tributary mouths, main channel or side channel backwaters, side sloughs, and upland slough habitats. This sampling effort should create winter macrohabitat preference criteria and habitat models for site specific habitat variables. Sampling should be done monthly.

The sample size of observations in each macrohabitat during the winter must be sufficient to run basic statistics and arrive at preference criteria.

Currently too few macrohabitat where sampled mid-winter to arrive at statically meaningful conclusions of habitat criteria.

The study was not conducted as provided for in the study plan because these are studies based on the scientific method which requires replication to be valid.

Modification 4-10: NMFS recommends HSC/HSI curves should be developed for fish behavioral response to short-term flow fluctuations (i.e., ramping) under the proposed OS-1b/ILF-1.

Ramping from 4,000 cfs to 12,000 cfs twice daily will change the habitat that fish select. At some life stages certain species will move in and out of habitats that are dewatered on a daily basis. Other species will simply abandon using these habitats.

Currently there is no information on how fish change their selection of habitat in a river subject to extreme winter ramping.

The study design did not suggest a way to take into account habitat selection changes due to ramping and this makes it impossible to assess the complete effects of the projects. The study, as conducted, will not meet the overall goal of assessing projects effects.

Objective 5*: Develop integrated aquatic habitat models that produce a time series of data for a variety of biological metrics under existing conditions and alternative operational scenarios.*

These metrics may include (but are not limited to) the following:

- Water surface elevation at selected river locations to assess breaching flows and lateral habitat connectivity
- Water depth and velocity within study areas subdivisions (cells or transects) over a range of flows during seasonal conditions
- Length of edge habitats in main channel and off-channel habitats
- Habitat area associated with off-channel habitats
- Clear water zone areas
- Effective spawning and incubation habitats
- Varial zone area
- Frequency and duration of exposure/inundation of the varial zone at selected river locations
- Habitat suitability curves (HSC) and habitat suitability indices (HSI) for specified species and life stages
- Weighted usable area (WUA) for specified species and life stages.

Objective 5 addresses aquatic habitat models that use data from existing pre-Project conditions to predict and quantify post-Project conditions of habitat alteration. Post-Project conditions refer to those under any proposed operational scenario of the hydropower dam. For the purposes of this review, the only proposed operational scenario is the newly identified ILF-1.

Several empirical and numeric models are proposed to model Susitna River riverine processes and fish habitat. Objective 5 addresses the hydrodynamic component of the river habitat through the use of 1-Dimensional (1D) and 2-Dimensional (2D) numerical models. In order for the models to be useful, they must be able to model both pre- and post-Project conditions of the Susitna River, including novel conditions. Data inputs and outputs that are provided by the models must be spatially and temporally relevant in order to properly integrate each of the multidisciplinary study components. Conditions, assumptions and limitations of all models under consideration should be made transparent to understand the resolution and accuracy of model inputs and results. This is very important because model results will be used to make decisions about Project operations based on modeled results of habitat and aquatic resources. Data collection efforts must also provide appropriate data sets for model calibration as well as the ability to validate model results under existing conditions.

The various models used for the Susitna-Watana dam Project are complex. Stakeholders have not been provided proof of the ability to integrate the models and apply results for purposes of assessing overall Project effects. In order to interpret the integrity of the model results, we need to understand hydraulic conditions, operational scenarios, modeling parameters, and boundary conditions used. These are the underlying concepts and concerns related to Objective 5.

FERC Study Plan Determination (SPD) comments: Proposed methods for specific instream flow model selection and development include a combination of approaches depending on habitat types and their biological importance, and the particular instream flow concern being evaluated.

FERC recommended the development of biologic data time series necessary for habitat specific modeling. The recommendation included expanded monitoring of spawning within FAs to include species specific information, especially given that the proposed Project would likely affect spawning habitat within mainstem habitats for all five species of Pacific salmon (section 5.9(b)(5)). FERC also recommended that AEA monitor surface and intergravel water temperature, DO, and water stage at Chinook, Pink, and Coho Salmon spawning locations within Middle River FAs.[3]

Methods for Objective 5

Proposed methods: MWH-ROM has been proposed for reservoir modeling, 1D HEC-RAS for open water flow-routing, River 1D to model ice processes, and River 2D to model open water flows in the Middle River FAs. Modeling in the Lower River is proposed to be 1D modeling at “select” sites and currently there are only two FAs study sites at the upper extent of the Lower River.

[3] FERC study plan determination April 2013 Page B-89

Just above the proposed Watana dam site, MWH-ROM will be used to model the reservoir instream flow reservation and power curves of water delivery to provide outputs of river discharge downstream of the proposed dam. Reservoir model outputs become the inputs for the 1D HEC-RAS OWFRM which extends to the Lower River. HEC-RAS 1D allows for the modeling of mainstem open water flow routing, but is not able to properly account for the flow routing outside of the mainstem in complex lateral side channel habitats.

River 1D is proposed to model winter flows during the ice covered period. Output from the 1D HEC-RAS or River 1D, depending on the time of year, provide water elevation and discharge at a given time step (time and date) and location. Outputs from the 1D modeling provide the starting input data for the River 2D modeling in Middle River FAs.

The ISR states that "Each Focus Area is the subject of intensive investigation by multiple resource disciplines including water quality (5.6), geomorphology (6.5), fluvial geomorphology modeling (6.6), groundwater (7.5), ice processes (7.6), fish and aquatics instream flow (8.5) and riparian instream flow (8.6)." (ISF ISR Appendix N p. 6.) 2D modeling in FAs allows for a more detailed understanding of complex flow patterns under various Project operational scenarios.

As an example, to start FA modeling in the Middle River for a given date and time during 1985, the analysis will use output from the 1D HEC-RAS OWFRM or River 1D ice process model for that particular time step. One of the 1D model outputs will consist of discharge and corresponding water surface elevation for a given location and time step (date and time) which are required as inputs to the River 2D model being used in the Middle river FAs.

Existing conditions for channel geometry (mainstem and FAs) come from ADCP and bathymetry profile data. Measured channel geometry data are used as inputs for the 1D HEC-RAS, River 1D and River 2D models. To run historical flows at time 0 (present conditions) along the mainstem Susitna River channel geometry, for example, 1D cross section measurements and LiDAR are used. In the FAs where 2D modeling is being conducted, more detailed measurements of the channel geometry have been collected using the ADCP and bathymetry profiles at a much finer scale (1-10 meters) laterally compared to the main stem (> 10 meters) and include longitudinal traces as well as lateral traces throughout the entire FA in order to define complex lateral channel habitats.

To address breaching flows and habitat connectivity, the ISR states, "The main goal of the connectivity analyses will be to evaluate the potential effects of Project operations on flow conditions that are related to the connectivity of and accessibility of fish habitats within Focus Areas and tributaries."

AEA proposed to collect data to model the varial zone, stranding and trapping, spawning and incubation, and breaching flows within FAs. A varial zone analysis would quantify frequency, magnitude, and timing of downramping rates by geomorphic reach downstream of the dam. Reach-averaged downramping rates under existing conditions and alternative operating scenarios would be provided for selected hydrologic years. Using the results of the 1D mainstem flow routing models, an algorithmic analysis would be conducted to identify specific hourly time periods when the water surface elevations are decreasing (i.e., downramping). For those time periods, the hourly reduction in water surface elevation would then be computed in units of inches per hour. A frequency analysis would be conducted on the downramping hourly reduction in water surface elevation to determine the number of downramping events exceeding a given threshold or limit of numerical indices of water surface elevations.

The frequency, number, and timing of downramping events following varying periods of inundation would be quantified to evaluate the effects on aquatic organisms. The varial zone analysis is proposed to be conducted by FA or by discrete habitat types within a FA (e.g., main channel, side channel, and slough) using an hourly time step integrated over a specified period.

The analysis to evaluate ramping rates will be done for different operational scenarios; hydrologic time periods (e.g., ice-free periods: spring, summer, fall; ice-covered period - winter will rely on Ice Processes Model – Section 7.6); water year types (wet, dry, normal); biologically sensitive periods (e.g., migration, spawning, incubation, rearing); and, will allow for quantification of Project operational effects on the following:

- Habitat area (e. g., main channel, side channel, slough) by species and life stage. This will also allow for an evaluation of breaching flows by habitat area and biologically sensitive periods (e.g., breaching flows in side channels during egg incubation period resulting in temperature change).
- Varial zone (i.e., the area that may become periodically dewatered due to Project operations, subjecting fish to potential stranding and trapping and resulting in reduced potential invertebrate production. This will occur under the hourly ramping rates of ILF-1 load following operation, for example).
- Effective spawning areas for fish species (i.e., spawning sites that remain wetted through egg incubation and hatching).
- Riverine processes that will be the focus of geomorphology (6.5), water quality modeling (5.5), and ice processes (7.6) studies including mobilization and transport of sediments, channel form and function, water temperature regime, ice formation and timing of ice decay. The IFS studies will be closely linked with these studies and will incorporate multi-discipline model outputs to provide comprehensive evaluation of instream flow-related effects on fish and aquatic biota and habitats.

AEA proposed to use the OWFRM in conjunction with the varial zone analysis to assess the potential for stranding and trapping. The OWFRM will be used to track hourly water-level fluctuations and calculate numerical indices of water surface elevation (WSE) representing the potential for stranding and trapping of aquatic biota. Numerical indices for predicting stranding and trapping are based on equations or thresholds that relate physical characteristics of habitats to the potential for stranding and trapping in those habitats. Physical habitat site characteristics for the stranding and trapping analysis would be derived from bathymetry and GIS mapping. GPS data collected in the field (river topography) provides elevation data used throughout the analysis of Project effects. The hourly WSEs would provide the basis for identifying when (and for how long) a habitat site becomes dewatered or disconnected from the main channel.

An effective spawning and incubation analysis is proposed to identify potential hourly use of discrete channel areas (cells) by spawning salmonids. Use of each cell by spawning fish will be assumed if the minimum water depth is suitable and velocity and substrate suitability indices are within an acceptable range defined by HSC/HSI. Species-specific HSC/HSI information used to identify potential use of a cell by spawning fish is being developed under ISF 8.5 Objective 4. If suitable spawning conditions exist, that cell would be tracked on an hourly time step from the initiating time step through emergence to predict whether eggs and alevin within that cell were subject to interrupted upwelling, dewatering, scour, freezing, or unsuitable water quality.

The effective spawning and incubation analysis was proposed for each of the FA considered to be representative of suitable spawning habitat. Results of the temporal and spatial habitat analysis would be a reach-averaged area calculated by weighting the effective spawning and incubation area derived for each FA by the proportion of FA within the geomorphic reach. The results would be calculated in terms of WUA and would not represent actual area dimensions utilized by a specific species and lifestage. The results cannot be used to calculate numbers of emergent fry for example, but instead would provide habitat indicators that would be used to conduct comparative analyses of alternative operating scenarios under various hydrologic conditions.

Temporal and spatial GIS model: An integrated resource analysis (IRA) was proposed as the decision support system (DSS). The DSS would use Project hydrology, operational scenarios, OWFRM results, and the habitat-flow response models (FA stranding and trapping, varial zone, spatial and temporal analysis, FA SWE models, effective spawning and incubation flow response curves) to estimate spatially explicit habitat changes over time. Several analytical tools would be utilized for evaluating Project effects on a temporal basis. The analysis would include habitat-time series representing quantified habitat as a result of differing flow conditions by time step (e.g., daily, weekly, monthly). Separate analyses would be conducted to address effects of ramping rates (e.g., hourly) on habitat availability and suitability.

An extrapolation process using spatial analysis of flow-habitat relationships was proposed to determine how field data from each study discipline collected at one location relates to other unmeasured locations. The spatial analysis would feed directly into the IRA proposed “to be completed during the 2014 study season after all data are collected and respective models have been developed.” Similar to the temporal analysis, the final procedures for completing the spatial analysis would be developed collaboratively with the TWG and with input from other resource disciplines.

The results of the IRA analyses would include various habitat indicator values (i.e., effective spawning and incubation habitat) under existing and alternative flow regimes. The analysis will be used to determine when/where there is available habitat. This can only be determined by conducting an IRA which uses the output from numerous models to determine habitat changes over time. Model results would be developed for representative hydrologic conditions and a multi-year, continuous hydrologic record to evaluate annual variations in indicator values. The availability of indicator values over a multi-year record would support sensitivity analyses of the habitat indicators used to evaluate proposed reservoir operations. Integrating the level of uncertainty in the various model components would provide an overall understanding of the robustness of individual habitat indicators. A multi-year analysis of habitat indicators would identify the sensitivity of indicators to hydrologic conditions and the level of uncertainty associated with decision-making under alternative instream flow regimes. The design of the sensitivity analyses would be developed by the Project Proponent and reviewed in consultation with the TWG. This was scheduled to happen during the fourth quarter of 2013 and implemented in the third and fourth quarters of 2014.

Implemented Methods: In the ISR a "proof of concept" (POC) is presented to demonstrate the Project's generalized Middle river habitat modeling efforts. The POC relies on integrated studies to provide reach scale and FA scale data inputs to models to determine Project effects on Susitna River aquatic resources. Results of an effects-analysis at the FA scale were limited to FA 8a (Skull Creek) and FA-128 and did not include all interdisciplinary inputs (e. g., microhabitat scale groundwater measurement).

During 2013 and 2014, HSC/HSI preference curve development efforts included: (1) preliminary selection of target species and life stages; (2) development of draft HSC curves using existing information; and (3) collection of site-specific HSC/HSI data from selected areas. This information and these data are used to develop both habitat use and preference curves for target fish species (AEA 2014). As an example, the ISR presented results of preliminary curve development using 2013 Chum Salmon spawning and Coho Salmon (< 50 mm) rearing (during the open water period) data.

Initial univariate modeling was used to select Chum Salmon spawning microhabitat variables (8.5 Fish and Aquatics Instream Flow study, Part C 2 of 2, Appendix M: Habitat Suitability Curve Development) for input to the multivariate model. We have not provided our review of Appendix M as AEA has stated that this information was superseded by ISR Part D, 2014-2015 SIR, Appendix D. Our review of the Part D SIR is included in this document under Objective 4.

On September 17, 2014, after the release of the June 2014 ISR, AEA released the Evaluation of Relationships between Fish Abundance and Specific Microhabitat Variables Technical Memorandum. The Technical Memorandum was to address FERC's requirement to assess microhabitat variables that may be used to assess Project effects. We are not providing our review of this Technical Memorandum because it is our understanding that this Technical Memorandum is also superseded with ISR Part D, 2014-2015 SIR, Appendix D.

Variances for Objective 5

Inadequate data: The overarching variance for the ISF aquatic habitat modeling noted by NMFS is that the time series cannot be developed until a minimum of two consecutive years of data collection has occurred. Year one of study data collection occurred during 2013, and according to the Project Proponent the second year of data collection for the majority of the FA's occurred in 2014. However, at this time NMFS does not consider the 2014 data collection as "second year data" since the first year of data collection (2013) has not been officially approved by FERC through the ILP process. In addition, winter data collection across disciplines is limited.

A variance of incomplete FA interdisciplinary data collection in 2013 was reported with the statement that this would not impact the ability to achieve study objectives (also addressed under Objective 2). The absence of temporal and spatial sampling of interdisciplinary studies across FAs impacts the ability to complete Instream Flow (8.5) analyses (under other 8.5 Objectives) in reaches without sufficient data. Currently there are some FAs with two years of data for an individual discipline, (i.e., 1D and 2D hydraulic modeling data in Slough 8A for the groundwater study) but data collection in several FAs is not complete for interdisciplinary studies.

Model Extrapolation*:* Approaches to temporal and spatial habitat model extrapolation were scheduled to be collaboratively developed by the fourth quarter of 2013. This schedule was not met, but instead the Project hosted study integration meetings to discuss how models could be used to answer biologic questions. The first meeting was the Riverine Modeling Integration Meeting (RMIM November 13-15, 2013) and the second meeting was the Proof of Concept Meeting (POC April 4, 2014). During the meetings it was realized that much of the information needed to develop aquatic habitat specific models was not yet available and that some studies needed modification in order to be integrative. AEA stated that not having a meeting to discuss potential methods for spatial and temporal habitat model extrapolation with the agencies in the fourth quarter of 2013 would not affect the Project's ability to meet study objectives or change the schedule for completing instream flow studies. Final approaches to address stakeholders concerns were deferred to 2015.

A discussion and presentation of general concepts of approaches for model extrapolation and the development of an IRA to assess the Project effects are provided in the ISR, no detail is given. This is critical information for determining the applicability of the methods and framework that will be used to integrate numerous study results/outputs proposed to assess Susitna River Project effects on natural resources.

Conformance with Objective 5

Although an update on ongoing habitat-specific 1D-and 2D-model development, preliminary POC application for FA-104, and initial development of WUA analyses were discussed in the ISR, habitat modeling results were not presented. Therefore, a detailed assessment of the habitat modeling analysis/output cannot be provided at this time. Although no results were presented within the ISR, NMFS has concerns related to the development of the habitat-specific models, the proposed analyses in the ISR, and the Project's current state of conformance with Objectives 5-8 in order to meet the licensing process timeline. There are many complex analyses to do, and limited time under the ILP to run models, QA/QC efforts, and allow for an iterative review process before the draft and final license applications would be due. Some specific concerns related to the developmental status of models are mentioned below.

Aquatic habitat modeling is based on outputs from interdisciplinary studies—groundwater (7.5), water quality (5.5-5.7), ice processes (7.6), and geomorphology (6.5 and 6.6). Currently the HSC are being developed through a "best fit" analysis for a number of microhabitat variables to determine significant predictors of habitat use and preference for a given species and life stage. If a microhabitat variable is not found to be significant then it is dropped from the HSC development. However, what might not be significant within a FA (i.e., temperature) may have significant effect post Project or outside of the FA.

One way to account for the multitude of variables that are linked to habitat quality is to integrate these requirements/preferences in a GIS-project analysis rather than trying to include all of them in the HSC development. This could help account for the full suite of variables that resource agencies have requested. This GIS approach using a range of acceptable values (e. g., thresholds) would be implemented based on whether habitat conditions fall inside or outside of acceptable values for a given species/life stage. This would require a referenced spatial layer analysis where each habitat "condition" has to be true in order for it to be considered "good" or available habitat. The effective habitat would then be determined based on whether the habitat conditions fall within or outside of the acceptable values for a given species and life stage. AEA appears to be attempting to use this type of GIS analysis for variables such as groundwater upwelling, scour, substrate, cover, and distance to cover. However, it is unclear if plans are in place to follow through with the GIS analysis or incorporate additional variables at requested scales. In addition, NMFS has concerns about whether the data collected under each of the independent study disciplines are able to be used to address the detailed habitat criteria that are required to assess effects throughout the Project area. For example, water quality and groundwater are part of the integration component to determine effective spawning and incubation habitat, and it is not clear that the data is being collected at the appropriate scale to be able to answer that question for a given "cell" within FAs. It is also not clear what modeling steps occur when results from various physical models do not agree (e.g., 2D hydraulic model shows presence of water in off-channel locations but the water quality model shows no water present).

The metric generated from habitat-flow relationships for fish and macro-invertebrate species and lifestages is expressed as WUA. WUA is an index of habitat area provided at a given flow. The general approach and application of WUA metrics are described in the ISR in Section 8.5.6.4.1 and Figures 8.5.6-11 through 8.5.6-22. In the ISR and at the POC meeting, WUA and available/effective habitat calculations for a given time series for a given species and lifestage within a given FA (i.e., FA128) were demonstrated. However, the details of these analyses have not been described nor have they been decided for the full range of species and lifestages and study sites with input from the TWG. Additional details of model linkages and both spatial and temporal scales used to calculate WUA metrics to determine Project effects on instream flow habitat for various species and lifestages throughout the Susitna River are needed.

WUA is being used in Middle River FAs to model existing conditions and Project effects. In the Lower River, WUA is being used for limited analyses and it does not appear that the analyses will include anything in the Lower River outside of the 1D representative sites. Currently there are two Lower River WUA "study sites," which may be too few to represent the entire Lower River.

Proposed methods for conducting habitat modeling under winter ice conditions in the Lower River are not included in the ISR. The Project's ability to model flows under winter ice conditions is a significant concern that is yet to be resolved.

Model Extrapolation (from FAs throughout the river): The ISR states that there are four options under consideration for extrapolating temporal and spatial habitat analysis outside of FAs. Extrapolation of FA conditions would lead to system-wide analysis, and made possible by developing a DSS. It is concerning at this point that the Project is without an understanding of how the habitat data will be used or integrated; or how outcomes from analytical methods are anticipated to influence results. There are several weak points presented regarding the effective combination of quantified fish habitat preference (e. g., fish observational data) and utilization curves, measurement of physical conditions, and ability to predict physical conditions under Project alternatives that are required for successful implementation of the aquatic habitat modeling. Weaknesses that NMFS identified in the aquatic habitat modeling are discussed below.

Lateral habitat groundwater and water quality—Scale: Based on the description in the ISR the lateral habitat (off-channel habitat) and water quality analysis will provide categorical zones (e.g. “bins”) of groundwater flux (upwelling, downwelling, neutral), temperature, and DO for most of these habitats. These categorical zones for the unmodeled habitat variables in off-channel habitats associated with groundwater and water quality will not be comparable to the much finer scale individual cell-specific hydraulic conditions (i.e., depth and velocity) associated with the 2D hydrodynamic modeling. This is because the groundwater and water quality data and models are at a much coarser scale and therefore the results for a given area are applied over a much larger scale. The 2D hydrodynamic model results are on a scale of 1-10 meter grids while the water quality results are on a 30-100 meter grid, and the groundwater is on an even larger scale. Therefore a single “cell” value for water quality gets applied to 30-100 cells in the hydraulic model. Detecting and estimating how the categorically zoned variables change under post-Project conditions (different stages, main channel temperatures, and bed topography) will be very difficult. We do not understand how a robust analysis of all relevant habitat variables will be achieved. This is especially problematic because off-channel habitats are very important for fish and because the physical variables not yet modeled are significant (relative to depth and velocity) and influential to fish use of these habitats.

Winter Habitat—Scale and Unobservable conditions: The winter habitat assessment has the same potential scale issues as the lateral habitat assessment (e.g., water quality and groundwater upwelling) with additional concerns surrounding sampling effort and fish habitat response curve characterization. The winter habitat assessment lacks the ability to predict winter fish habitat preference for novel conditions that are currently unobservable (e.g., new mid-winter ice-free reaches under post-Project operations).

The ISR describes long-term 1D moveable bed simulation, short-term 2D moveable bed simulation, 1D ice-formation simulation, and short-term breakup simulation experiments related to channel alteration. It will be challenging to integrate multiple alterations of channel geometry with habitat valuations calculated from fixed geometry – especially given the episodic and difficult-to-model or observe geomorphic effects of mechanical ice breakup. It is likely that ice breakup may cause more channel disturbance than what occurs during open-water conditions. If we are not able to model predictively how ice breakup and ice dams alter the channel geometry then we can’t really assess how Project operations will change the channel geometry or resulting habitats. This will result in massive uncertainty in predicted post-Project impacts.

Varial zone analysis: "Varial" zones resulting from intra-daily flow fluctuations (i.e., down ramping) have dramatic primary and secondary effects on fish. Primary effects include fish stranding while secondary effects include mixing of mainstem surface water with longer-residence water and groundwater in lateral habitats. Effects on fish habitat include reduced habitat complexity and disconnection of habitats (e.g., proximal feeding and rearing areas). Even if we could confidently predict the resulting physical habitat conditions, there are no Susitna River field data specific to effects of down ramping to support fish response curves or the development of HSC for repeated intra-daily flow fluctuation. This is a problem for both model prediction and validation capabilities for the proposed load-following operational scenario.

Modification 5-1: Increase sampling effort of subsurface (inter-gravel) water temperature and DO measurements at each FA to address Chum Salmon incubation. Subsurface water temperature and DO data should be integrated with the 3D groundwater models to develop HSC curves and WUA analyses.

Salmon egg development is dependent on a continuous sufficient supply of water with sufficient dissolved oxygen passing through the spawning gravels. The rate of development is dependent on water temperature. To assess dam effects we need to know the conditions that currently exist where Chum Salmon spawn. These two variables are essential to the predictive modeling necessary for Project effects analysis of aquatic resources.

DO and water temperature metrics seem to be only occasionally collected and to be second string to water depth and velocity.

The study was not conducted as provided for in the approved study plan because as implemented it is not scientifically rigorous and therefor does not allow for project effects to be quantified.

Modification 5-2: Compile a comprehensive aquatic habitat water quality report of interdisciplinary data collection efforts. This should include all QA/QC procedures and results (calibration dates, quality objectives, accuracy and precision calculations) as part of the ISF (8.5) study, or Water Quality (5.5, 5.6, 5.7) studies or new Model Integration study.

Compared to the length of river potentially affected, not a lot of water quality data exists. If all the data was collected in a single location it would be easier to understand. The logical location for this report would be in study 5.5. All temperature data collected as part of groundwater 7.5, any data from 8.5 and the water quality data from 5.5 and 5.7 should all be put in this one place and analyzed together.

Currently data is scattered which makes it hard to know what data exist, and very difficult to interpret it.

The study was not conducted as provided for in the approved study plan.

Modification 5-3: NMFS recommends breaching flows and habitat connectivity analysis should be conducted on biologically relevant timelines; such as every five years, which is the average generational lifespan of a Chinook Salmon. Alterations to channel geometry conditions should address breaching flows of both main channel *and* lateral habitats because these habitats support critical life stages including spawning, incubation, rearing and migration.

Breaching of the berm at the head of a side slough is an important event in the life of a juvenile salmon. Within minutes to hour, the water becomes more turbid, cooler, and faster. Currently the number of breaches in a given year is a probability game, with a reasonable chance of at least one breaching event and a minute chance of exceeding some upper limit of breaching events. NMFS needs to know that there will a similar number of sloughs with similar breaching odds once the dam is built.

The results to date do not state whether the berms will become hardened and grow trees, stay the same, or be washed out and not function as berms at all. The POC meetings suggest that Geomorphology Modeling (6.6), Groundwater modeling (7.5), Riparian Vegetation predictions (8.6) and the OWFRM (8.6) will interact on some regular time step such that the fate of berms can be projected. It would be helpful to know that 20% of slough heads close off in the first decade and another 30% by year 50, but that the remaining 50% have an explainable self-maintenance function that will remain intact in a post dam scenario. The current models do not seem to be able to accomplish this. Without working models, it is reasonable to conclude that these sloughs, which are critical to salmon rearing, will slowly fill in with vegetation.

The study was not conducted as provided for in the approved study plan because time series of data regarding the predicted status of head of slough berms does not exist.

Modification 5-4: NMFS recommends that AEA describe and then predict the extent of warmer winter aquatic habitats that have not previously been observed on the Susitna.

Some areas immediately below the dam will not ever freeze or only during very brief extreme cold snaps due to the five-fold increase in 4° C, highly oxygenated water exiting the dam. Will this be the norm for only the first ½ mile below the dam or will it extend down 50 miles? Will it greatly help rearing salmon or/and will it increase the number of salmon predators such as Northern Pike? Were other rivers that stay warm in Interior Alaska reviewed as analogous situations? Although the water chemistry is very different, these new temperature might mimic conditions in hot spring-fed rivers like the Chena.

The information presented to date does not acknowledge the two FAs between Devils Canyon and the dam site are likely to create novel and unique environments which will attract a slightly different mix of species. This is analogous to unnaturally deep pools created by mining in some rivers in the Sierra Nevada Mountains that now act as refuge for catfish (which are known to eat salmon fry). Positive effects are also possible. Post project, out migrating juveniles which were moved over the dam by helicopter, might be deposited at this location.

The study was not conducted as provided for in the approved study plan as very little data has been collected at the Stephens Complex and Watana FAs and no effort has been made to quantify the potential magnitude of change immediately below the dam.

Modification 5-5: NMFS recommends that an uncertainty analysis of results of aquatic habitat models should be completed, so stakeholders can understand limitations of each model used to assess potential project effects. How this analysis is conducted should be transparent to all stakeholders.

When the HSC/HIS habitat characterization described in objective 4 is complete, it could still be difficult to understand whether the information is useful. The curves might be very good at predicting Chinook Salmon juvenile habitat such as 85% of the juvenile were found in the environments described by the curves. However, it could be poor for predicting Coho Salmon habitat because although they tend towards certain habitat; over half the juveniles were found in habitat is not described by the curves. Similar to needing to understand uncertainty in channel morphology and ice process models, we need to know how well we understand the habitat requirements of the various species.

Appropriate habitat suitability curves for salmon in the Sustina have not yet been presented due to the challenges described in objective 4. The issue of uncertainty has not been discussed.

The study was not conducted as provided for in the approved study plan because the aquatic models cannot be meaningfully integrated without understanding uncertainty in aquatic habitat.

Modification 5-6: NMFS recommends thoroughly addressing the ability to model stranding and trapping under the rapid and perpetual flow fluctuations in side channels and side sloughs during proposed winter flows.

If juvenile fish are stranded on bare gravel mid-winter the availability of excellent habitat the next day will be null.

The SP indicates that “field surveys will be conducted at potential stranding and trapping areas on an opportunistic basis following up to three flow reduction events during 2013.” Opportunistic observations of potential stranding and trapping areas were recorded during substrate classification surveys conducted during falling river stage conditions in September 2013. There needs to be more focus on this important process.

While the observations may need to be opportunistic the overall study of stranding and trapping needs more definition. The study, as conducted, will not meet the overall goal of assessing projects effects.

Modification 5-7: NMFS recommends AEA addressing the need to provide habitat persistence for holding (e.g., at tributary mouths) by developing thresholds for lateral and longitudinal geomorphic habitat change and connectivity and alterations to the hydrograph.

For smaller tributaries, fish often hold for a period of days to weeks waiting for an appropriate flow to move up the tributary and spawn. To evaluate the projects effects on these fish, the stakeholders need to know if the holding areas will still exist.

Currently the coarseness of the HEC-RAS Bed evolution model does not seem allow for such precision.

The study, as conducted, will not meet the overall goal of assessing projects effects.

Objective 6*: Evaluate existing conditions and alternative operational scenarios using a hydrologic database that includes specific years or portions of annual hydrographs for wet, average, and dry hydrologic conditions and warm and cold Pacific Decadal Oscillation (PDO) phases.*

FERC Study Plan Determination (SPD) comments: FERC requires that the run-of-river (ROR) operational scenario be evaluated for the Susitna- Watana Dam hydropower Project.

Methods for Objective 6

Proposed: The Project Proponents proposed to evaluate the Susitna-Watana hydropower Project under the OS-1b load-following operational scenario.

Implemented: The ISR and supporting documents do not provide sufficient information related to how the Project will be operated (scenarios) during construction or after construction. The only Project scenario provided in the initial ISR was related to Max-load following (OS-1b) which was described as a worst case scenario but would most likely not be how the project would be operated. In the latest 8.5 SIR (Nov 2015) OS-1b was replaced with a modified scenario to reduce powerhouse discharge variability through assigning peak mode operation to other existing hydropower plants on the Railbelt grid (Integrated Load Following [ILF]-1). AEA states that other ILF operations may be evaluated during the impact assessment but currently is only modeling the ILF-1 scenario.

Overall the OWFRM (Version 2.8) results demonstrate the general ability to simulate the flow hydrograph through the main channel of the Susitna River during open-water conditions. Comparison of hydrographs and stage changes associated with pre- and post-Project (OS-1b) operations at Gold Creek and Susitna Station locations throughout the Middle River are presented and provide adequate information to address the study objectives in the Middle River under the OS-1b operations. Other than the newly identified ILF-1 operational scenario which will replace OS-1b in the final OWFRM (Version 3.0), no additional operational scenarios are discussed or presented.

Initial flow routing results confirm that post-Project OS-1b operations will drastically change the flow hydrograph in the Middle River throughout the open-water portion of the year resulting in maximum potential stage changes ranging from 9.7 feet near the dam, 5.7 feet near Gold creek, and 2.1 feet near Susitna Station in the Lower River. This amount of stage change is significant in terms of river connectivity and the effects on main channel and lateral off-channel habitats. Additionally, the hourly stage affects associated with ramping rates for OS-1b ranged from 0-2.1 feet under dry conditions and 0-8.0 feet under wet conditions near the dam site, 0-4.1 feet near Gold Creek, and 0-4.0 feet near the Sunshine gage in the upper extent of the Lower River. While OS-1b is considered a "worst-case" scenario**,** this illustrates that the ramping rates associated with a hydro-peaking operation will have drastic effects on the water surface elevations throughout the river greatly affecting habitat conditions, lateral habitat connectivity, river processes (instream flow and riparian), ice processes (flow under and over existing ice formations), aquatic habitats and fish species and populations.

During the September 9-11, 2014 Fish Passage Brainstorming Workshop AEA's consultant, Mr. John Happla of MWH, presented a new Operational Scenario referenced as "ILF-1 Intermediate Load Following." ILF-1 was also briefly presented by Jon Zufelt (HDR) during a seminar hosted by USGS on Susitna River Ice Processes (January 15, 2015). Mr. Zufelt stated that this operational scenario would also result in "significant jumps and surges" in discharge throughout the Susitna River. The ILF-1 scenario assumes that the other Railbelt hydropower plants (Bradley Lake, Eklutna Lake and Cooper Lake) will provide load-following to the extent possible. Susitna-Watana would be assigned the remainder of the load-following, with none assigned to the thermal resources." The presentation summarized Project operational scenarios analyzed, based on the Physical, Hydrologic & Engineering Information (Information Items P3 – P5), Operating Scenarios OS-1b and ILF-1, [Sept 9-11, 2014 by MWH information posted to AEA's Susitna-Watana web site]. OS-1b is a maximum load-following scenario being used as a boundary case with maximum variation on hourly, daily, and seasonal time scales. Flow duration curves were presented, along with flow through the turbines, flow through fixed cone valves and reservoir elevation duration curves. ILF-1 is an intermediate load-following scenario that includes using load following at other Railbelt hydropower resources which can accommodate approximately one half of the Railbelt's load variation. In addition, spring inflow forecasting was added to the model. Flow duration curves and reservoir elevation duration curves were presented for both scenarios. Under both operating scenarios the spillway gates are designed to not operate at less than the 50-year flood during full pool conditions. During simulation using 61 years of load and flow data at an hourly time scale, the spillway was never used. The simulations predict the turbines will run 100 percent of the time. The FPTT requested a summary of daily variation in outflow by month for both weekdays and weekends as a data request.

Variances for Objective 6

The ROR operational scenario has not been analyzed for pre- and post-Project scenarios as required by FERC.

Conformance with Objective 6

In the initial ISR, OS-1b load following scenario was presented as a worst-case scenario to demonstrate potential Project effects. In the latest SIR the OS-1b has been replaced with the ILF-1 scenario but no additional realistic operational scenarios, such as the ROR, have been presented. The options for minimizing overall Project effects from operational scenarios are not provided. In order to appropriately study the Project effects associated with post-Project operations, additional alternative operational scenarios in addition to the ILF-1 scenario must be evaluated. Alternative analyses are needed to better understand the overall Project effects throughout the extent of the Middle and Lower River. Understanding of operational scenarios should be linked temporally and spatially with the life history strategies of Susitna River fish species. This is critical information for determining the type and amount of alteration and the associated effects on instream flow and habitat conditions. Alternative operational scenarios should be evaluated to provide the best-case scenario for hydropower operations and species and habitat conservation.

Modification 6-1: NMFS recommends that other operating scenarios, including run-of-river, be evaluated and their effect on habitat availability be assess under various Pacific Decadal Oscillation scenarios. These alternative operating scenarios could be used as protection, mitigation and habitat conservation (PM&E). This recommendation is similar to 3.3 but it recommends completing the suite of evaluation steps that come once the OWFRM has been run.

In order to select an operation scenario that balances energy production with providing adequate fish habitat multiple scenarios must be evaluated.

The applicant has only partially evaluated full-load following (OS-1b) scenario which is insufficient. The ILF-1 was discussed in meetings but no results from this operations scenario have been presented.

Run-of-river was specifically required by FERC (4/1/2013). The study was not conducted as provided for in the approved study plan.

Objective 7*: Coordinate instream flow modeling and evaluation procedures with complementary study efforts including Riparian (see Section 8.6), Geomorphology (see Sections 6.5 and 6.6), Groundwater (see Section 7.5), Baseline Water Quality (see Section 5.5), Fish Passage Barriers (see Section 9.12), and Ice Processes (see Section 7.6) (see Figure 8.5-1). If channel conditions are expected to change over the license period, instream flow habitat modeling efforts will incorporate changes identified and quantified by riverine process studies.*

FERC Study Plan Determination (SPD) comments: The FERC SPD did not require additional information related to integration methodology or study detail. However, FERC noted that requests for study modifications can be made through the ISR review process.

FERC regulations specify that the need for additional years of studies would include, whether: (1) the study objectives were met during the two-year study period, (2) there was substantial variability in study results between study years, (3) the study was implemented under anomalous environmental conditions, and (4) the data collected are insufficient to conduct the environmental analysis pursuant to NEPA and inform the development of license requirements.

Methods for Objective 7

Proposed Methods: Objectives 5 and 7 are closely linked because the habitat specific models (Objective 5) rely on integration of multiple riverine, physical, and biologic studies.

The Instream Flow Study (ISF 8.5) is designed to characterize the existing, unregulated flow regime and the relationship of instream flow to riparian and aquatic habitats under alternative operational scenarios. The SP states that the proposed Project will alter stream flow, sediment and large woody debris transport downstream of the proposed dam site. These stressors will affect channel morphology and the quantity, quality, and timing of downstream habitats. The ISF framework will be used to assess Project effects on downstream habitats under existing channel conditions, and the prediction of future channel conditions under alternative operational scenarios.

Alternative operational scenarios will differentially affect fish habitats and riverine processes on both spatial and temporal scales. The Project's habitat and process models will therefore be spatially discrete (e.g., by FA, reach, and segment) yet integrated to allow for a holistic evaluation by alternative operational scenario. Effects of alternate operational scenarios stressors on resources are proposed to be assessed using measurable indicators of changes in habitat suitability, quality, and accessibility**.** The assessment requires an understanding of fish habitat use, including where and why fish preferentially select certain habitats over others.

Implemented Methods: There has been no demonstration, outside of the POC meeting, how the study will holistically evaluate Project effects. AEA stated that Project effects on Susitna River resources will require inventive modeling approaches that integrate aquatic habitat modeling with evaluation of riverine processes such as groundwater-surface water interactions, water quality, and ice processes.

Resource data collection was initiated in Q2 2013 and will continue during at least one more year of study. Model development is ongoing and will be completed during the next year of study prior to the USR under the ILP. Substantial effort, with involvement of stakeholders, is needed to advance the model integration effort. Model integration capabilities may be the limiting factor for Project effects assessment.

<u>Variances for Objective 7</u>

Project Proponents state that they have implemented the methods as described in the SP with no variances. As of March 2016 no integration of studies has occurred to convincingly demonstrate the effectiveness of the process.

<u>Conformance with Objective 7</u>

NMFS's RSP comments asked for more detail related to how field data, models, and assumptions from individual studies would be integrated to produce a set of metrics to support a comparison of alternatives. Currently, many of our concerns related to model integration stem from (1) the level of data collection is insufficient to support model development; (2) model capabilities are not established for both pre- and post-Project conditions; and, (3) the demonstrated ability to integrate models to quantify Project effects on fish habitat is lacking.

The relative time allocated to overall studies and study integration is an additional concern. The applicant has recently begun to acknowledge the importance of model integration, and small changes have been made to standardize data outputs. However, the models cannot be integrated at this time and uncertainty remains that they can be fully integrated. Flow routing and habitat mapping results did inform 2013 planning and adjustments (extension into Lower River reach and evaluation of representativeness of FAs). However, the time line was extremely compressed with some study results produced just before the plans for 2013 work were done (e.g., ice processes, 7.6). Some of the integration challenges will involve more sophisticated analyses and more fundamental influences of one study on another. An integrated analysis requiring synthesis across studies will require more time than is available in the planned licensing schedule. The overarching concern is that effective integrated analysis will not be achieved, with the end result being a collection of un-relatable information.

Another concern is that two years of biological and physical process sampling are insufficient to capture natural variability, collect adequate site-specific data, and build models to predict how Project operations will affect ecological relationships. Furthermore, proposed changes to the sampling designs may occur following one year of study, making year-to-year data comparisons difficult. Original requests were for a minimum of five years for all studies related to anadromous fisheries resources to cover the average lifespan of a Susitna River Chinook Salmon, the range of annual environmental variability, and collect sufficient data for model validation.

At the request of the Services and other stakeholders, AEA held a November 2013 Riverine Modeling Integration Meeting and an April 2014 POC meeting to demonstrate the viability of their approach to study integration.

The POC provided examples of how data from different disciplines will be used to evaluate potential Project effects on fish habitat. The POC meetings presented integration examples using the ISF flow routing study (8.5) to account for river flows leaving the dam, and for tributary and groundwater inputs resulting in data outputs providing water surface elevations, water depths, and water velocities at multiple cross-sections. The fluvial geomorphology (6.6) study uses the output from ISF flow routing (8.5) studies (1D open and ice covered models) and applies a 2D hydraulic model to estimate water depth, or stage, and water velocity through FAs. The ice processes (7.6) study uses a 1D model to estimate ice development through the winter. During winter, the ice process study uses a 2D hydraulic model, with a static and constant ice cover thickness which is a "best guess" as to the ice conditions at a FA, to estimate water depth and velocity throughout each FA. The reservoir and riverine water quality modeling (5.6) will be populated with measures of water quality and the 1D flow routing data, and 2D hydraulic data from the fluvial geomorphology (6.6) study to model water temperatures, and other parameters, in each FA. The groundwater study (7.5) uses locational data of groundwater discharge and showed how changes in mainstem flow altered sub-surface water temperatures to provide changes in water quality due to changes in surface-groundwater exchange.

Biological modelling presented in the POC used habitat suitability curves to evaluate potential Project effects on Chum Salmon spawning habitat and juvenile Coho Salmon (< 50 mm) summer habitat within FA-128 (Slough 8A). HSC for habitat suitability indices (HSI) were developed from field sampling results which measured fish presence along with multiple physical and water quality habitat components. HSC curves were developed for two species and life stages. HSC curves for Chum Salmon spawning included parameters for upwelling, substrate, water depth, water velocity, and site location. HSC curves for juvenile Coho Salmon included parameters for cover (present or absent) in clear water, turbidity (>50 NTU), water depth, and velocity.

The major limitations of the POC examples provided were (1) estimates of water depth and velocity during winter as a result of assuming a static 1m thick ice layer across the channel surface, (2) the lack of HSC curves and WUA analyses for Chum Salmon egg incubation that depend on subsurface water temperatures and DO, (3) HSC curves for juvenile Coho Salmon that do not assess variables influential to growth and survival and which can be altered by the Project, (4) HSC curves for juvenile Coho Salmon developed during the summer and applied equally during the winter, (5) the application of HSC curves for juvenile Coho Salmon which do not account for the different proportions of age class sizes over time, (6) confidence intervals in modeled water depth and velocity that are greater than the precision needed for HSC curves, (7) lack of water quality data and modeling in off-channel habitats, (8) lack of groundwater and water quality data for all FAs, (9) lack of Lower River Project data that will provide useful analyses of Project effects on salmon spawning and rearing.

After review of the POC and the difficulty in conducting study integration we are increasingly concerned that the current ILP licensing process does not allow time to develop useful integrated models capable of assessing Project effects. NMFS believes there is substantial work left to do to meet Objective 7.

Modification 7-1: This objective can best be achieved by implementing a New Study for Model Integration. This New Study Request is included in this filing as an enclosure.

Modification 7-2: In a single “pilot area” (probably an existing FA) run/coordinate all the current models and show the quantity and quality of various fish species macro and meso habitats over the next 50 years for two operating scenarios (full load following and one other) and no-project alternative.

The effects of the dam will take decades to be fully realized. Upland slough habitat used by juvenile Coho Salmon might continue to exist for the first decade but cease to exist as trees fill and dry out the sloughs after 30 years. Side slough habitat could be desiccated by the initial filling of the reservoir, but then return over time. NMFS requests that the applicant show that this extremely difficult long-term habitat analysis works and that logical comparison can be made between the effects of different operating scenarios.

While the applicant has focused on developing individually functional models, it is simply not clear that habitat can be modeled over the 50-year time span to produce comparable results between alternatives in even one small area. Demonstrating that the integration of models is successful in a pilot area would suggest that AEA’s efforts could lead to a useful product.

The approved studies were not conducted as provided for in the approved study plan because to date the model integration is not functioning.

Objective 8: *Develop a Decision Support System-type framework to conduct a variety of post processing comparative analyses derived from the output metrics estimated under aquatic habitat models. These include (but are not limited to) the following:*

- *Seasonal juvenile and adult fish rearing*

- *Habitat connectivity*
- *Spawning and egg incubation*
- *Juvenile fish stranding and trapping*
- *Ramping rates*
- *Distribution and abundance of benthic macro-invertebrates.*

FERC Study Plan Determination (SPD) comments: In the SP AEA stated, "Development of a DSS-type process, and supporting software to efficiently process data analyses, will be initiated in collaboration with the TWG after the initial results of the various habitat modeling efforts are available in 2014 (Table 8.5-14). The intent is to prepare the DSS-type evaluation process by Q1 2015 to assist scenario evaluations in support of the License Application."

Methods for Objective 8

Proposed: The 2014–2105 SIR states that AEA is planning to work with the licensing Participants to develop the DSS. The ISR stated that a DSS framework was initiated during 2013, and that the intention is to use an IRA "matrix method" as the basis for decision making. Stand-alone software for the DSS is no longer proposed.

Implemented: Development of the DSS is contingent on data collection and analysis, and subsequent development of resource specific models that will be used to assess Project operations. Data collection was initiated in quarter 2 of 2013 and will continue during the second year of study. Model development activities are ongoing and will be completed during the next year of study prior to the USR. As a result, the ISR is limited to presenting potential methods and approaches for developing the DSS and conducting an integrated resource analysis (IRA). These approaches were initially provided in the SP (RSP Section 8.5.4.8), and were discussed briefly during the November 13-15, 2013 IFS TT Riverine Modelers Integration Meeting.

Variances for Objective 8

No variances for Objective 8 were provided. However, NMFS considers it a variance that very little progress related to the DSS was made during 2014, 2015, or 2016. The DSS is critically important to understanding if the Project is collecting appropriate information to determine Project effects on fish and wildlife resources.

Conformance with Objective 8

Very little progress has been made on developing the DSS. The identification of an appropriate DSS is a Project component that should have been completed concurrently with the development of the initial SP. This is critical information for determining the applicability of the methods and framework that will be used to integrate the numerous study results/outputs proposed to assess the Project effects on natural resources throughout the Susitna River.

Modification 8-1: Objective 8 can best be achieved by implementing a New Study for Model Integration and DSS. This New Study Request is included in this filing as an enclosure.

Modification 8-2: NMFS recommends that the applicant produce tallies of different macro, meso, and micro habitats weighted by "value" to various organisms for each proposed alternative as is usual in the aquatic habitat approach. Emphasis should be on how the various modeling efforts can produce side-by-side comparisons of Project alternatives (including a no-Project alternative).

Various operating scenarios will necessarily change the amount of available habitat for each species in each of its life stages. For example at FA-128, full-load following might increase Coho Salmon rearing habitat but decrease Chinook Salmon spawning habitat. These comparisons will need to be made over many project reaches over many years and several climate scenarios. This is a herculean effort, but walking away from this effort means that stakeholders and the applicant should assume Susitna-Watana dam will have a similar level of environmental effects and species extirpation as other similar sized dams.

To date the focus has been on can the applicant arrive at how much habitat of each type will be available in post project scenarios. AEA believes these habitat values can be determined, and has implied that the DDS will logically combine hundreds of small habitat projections into single comparison of alternatives including no-project alternative. Until this final step has been spelled out it is not clear if this massive modeling effort will lead the applicant and stakeholders to the best decision.

The study was not completed as provided for in the approved study plan because the DDS does not exist.

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8.6 Riparian Instream Flow

ISR Review and Study Modifications

The following comments are based on the 2014 Initial Study Report (ISR) for the Riparian Instream Flow Study (ISR 8.6); a subsequent Study Implementation Report (SIR 8.6 2015) including a supplemental Part D (2015); and several Technical Memoranda (principally Geo-Watersheds Scientific and R2 Resource Consultants, Inc. 2014). Based on the June 2014 and March 2016 ISR meetings, and review of the Alaska Energy Authority's (AEA) relevant study 8.6 materials provided, the National Marine Fisheries Service (NMFS) submits the following comments and recommendation for study modifications.

Study Objectives

The study objectives as stated in the FERC study plan determination (4/1/2013) are:

1. Synthesize relevant existing physical and biological data related to Susitna River floodplain vegetation.
2. Delineate sections of the Susitna River with similar environments, vegetation, and riparian processes (termed riparian process domains), and select representative areas within each riparian process domain (termed focus areas), for use in detailed physical process and vegetation surveys and sampling.
3. Characterize the groundwater and surface water hydroregime requirements of seed dispersal and seedling establishment for several dominant riparian woody species.
4. Characterize the role of river ice in the establishment and recruitment of dominant floodplain vegetation, and develop a predictive model of the proposed project's potential operational impacts on ice processes and dominant floodplain vegetation establishment and recruitment.
5. Characterize the role of erosion and sediment deposition in the formation of floodplain surfaces, soils, and vegetation, and develop a predictive model of the proposed project's potential operational changes to erosion and sediment deposition patterns and associated floodplain vegetation.
6. Characterize the natural floodplain vegetation groundwater and surface water maintenance hydroregime, and develop a predictive model of the proposed project's potential changes to the natural hydroregime and potential floodplain vegetation.
7. Use spatially explicit GIS-based models to scale-up the study results and modeling from focus areas to riparian process domains.

NMFS Study Modifications

3-1 Estimate seedling winter mortality in order to understand which locations are likely to result in ultimate pole and tree recruitment, and to help identify the importance of asexual reproduction in recruiting mature stands.

G-1 (Global Modification) Conduct Detailed and careful analysis of the current data to determine which lines of investigation should be called complete and which should be pursued further. The study delay, i.e., the abeyance of the study process ordered by FERC, actually provides an opportunity to greatly improve/expand the vegetation studies because the time span is now longer growth trends will be easier to observe.

G-2 (Global Modification) Integrate the Riparian Instream flow with other studies specifically the 8.5 Open Water Flow Model and 6.6 Fluvial Modeling.

Review by Objective

Objective 1*: Literature Review of Dam Effects on Downstream Vegetation.*

Study methods are appropriate, and merging the review with the Fluvial Geomorphology Study (6.6) review into a single technical memorandum (R2 Resource Consultants, Inc. and Tetra Tech, Inc. 2014) resulted in a better product.

Objective 2: *Focus Area Selection−Riparian Process Domain (RPD) Delineation.*

Study methods are appropriate, and including satellite study sites to capture the variability in floodplain vegetation not found in the focus areas improves the level of information gathered for each RPD.

There remains some confusion about what constitutes pseudo-replication. One of Hurlbert's (1984) main points is about what level replication was conducted and how the results are used to make predictions based on inferential statistics. Thus, "…the number of adequate sample sites necessary to perform robust statistical analyses, is addressed in the hierarchical riparian process domain sampling design …" (ISR 8.6, Part A – Page 5, last paragraph) is only true if a sufficient number of focus areas per RPD are sampled to attain the desired power of the statistic. One to three focus areas per RPD (i.e., ISR 8.6, Appendix A, Figure 1) are unlikely to be sufficient for "robust statistical analyses."

The innovative way RPDs were delineated, and the focus areas selected to represent the RPDs, are appropriate. We caution, however, against claiming statistical rigor for scaling-up the results to RPDs. Results need to be scaled up to RPDs, but our level of confidence in the scaled-up results will need to be supported by means other than inferential statistics based on the current study design.

For ISR 8.6, Appendix A, we recommend normalizing the results by Project River Mile. As acknowledged in Appendix A, RPD 3 has the most herbaceous vegetation based on the total transect length per RPD (e.g., Figure 2), but this is also the longest riparian process domain in the Middle River so it might be expected to have the largest total areas. In contrast, if the vegetation area were normalized by river mile, then the relative distribution of vegetation within RPDs would be more apparent. A final iteration of RPD delineation will be necessary to incorporate variation in ice processes and additional Lower River area, as acknowledged in SIR 8.6 Part D (2015).

We continue to question the adequacy of the focus areas representing herbaceous vegetation for the RPDs, since the analyses used to justify selecting the focus areas (ISR 8.6, Section 5.2 refers to Appendix A) continues to lump all herbaceous communities into one community type (herbaceous), while a number of woody communities with much less representation in the RPDs were used to justify the representativeness of the focus area.

Objective 3: *Seed Dispersal and Seedling Establishment.*

The methods for study Objective 3 have two sub-elements: (1) synchrony of seed dispersal, hydrology, and local Susitna River valley climate; and (2) seedling establishment and recruitment. The methodology for synchrony of seed dispersal is appropriate, although it would be desirable to sample more *Salix spp* at PRM 88 (i.e., ISR 8.6, Table 5.3-1) if additional specimens are available at that site.

The methodology for seedling establishment and recruitment is reasonable. Changing the Final Study Plan (FSP) definition of balsam poplar and willow seedlings from plants with stems less than one-meter high to plants less than one year old, because it was difficult to differentiate between clonal and sexual recruitment without destructive sampling, was a good decision. Although not in the FSP, we recommend that AEA develop estimates of overwinter mortality of the seedlings because it is likely that winter mortality is very high in the presence of ice.

It will be important to continue to distinguish between seedling and asexual reproduction. Seedling cohorts need to be summarized not just by elevation, but hydraulic position (e.g. inundating discharge) in order to link seedling establishment with flooding characteristics, using flow records. It is also critical that seedling patterns be characterized by distances along transects, in order to discern positions of unique cohorts. Only in this way can any secondary recruitment be identified.

Modification 3-1: NMFS recommends estimating seedling winter mortality in order to get a sense of what locations are likely to result in ultimate pole and tree recruitment, and to help identify the importance of asexual reproduction in recruiting mature stand.

Dendrochronology will continue to be a key tool in making these distinctions, along with recording ages of individuals by transect distance.

In many dam projects in the southwest, trees and shrubs stabilize off channel areas and then over time cause them to dry out. If ice dams continue to be a formative process, this will be less of a concern on the Susitna. Knowing winter survival is important but may be easily determined by premeasuring the plots established in 2013 when the study resumes.

The study was not yet conducted as provided for in the approved study plan as it was not continued long enough to establish recruitment.

Objective 4: *River Ice Effects on Floodplain Vegetation.*

Objective 4 components are innovative, effective, and well developed. The ice scar mapping has continued through 2014 filling in sections of the Middle River and extending coverage into the Lower River. Preliminary results point to the importance of ice as a physical disturbance operating on a lateral extent that is large relative to open water flooding. Thus it may be important to characterize the frequency distribution of ice disturbance as a determinant of riparian succession and vegetation distribution. We recommend that although not critical as a requested study modification, that AEA explore how well multiple scarring events could be quantified by full “cookie” slabs (e.g., on downed or sacrificed trees). These cross-sections of the tree trunk can extend the historical frequency of scarring by revealing older ice scars that have completely grown over and are no longer detectable by external examination.

Objective 5: *Floodplain Stratigraphy and Floodplain Development.*

Work on this objective is being accomplished cooperatively with the Riparian Vegetation Study (11.6). Soil stratigraphy excavations are being conducted in association with Study 11.6 vegetation sampling locations, with a subset of the sediment cores being dated using radioisotopes. A substantial number of stratigraphic samples have been collected, including some collections from previously sampled vegetation plots in 2014. Some concerns have been raised about soil stratigraphy excavations occurring within permanent vegetation plots, but it seems reasonable to defer to the investigators to appropriately balance disturbance with slightly decoupling the soil and vegetation observations.

Less detail and progress has been reported for methods and measurement of erosion rates and integration of erosion with sediment accretion to produce synthetic analysis of floodplain turnover and development.

Objective 6*: Riparian Groundwater/Surfacewater Hydroregime and Plant Transpiration.*

The methods for this study component are relatively sophisticated and some of the work is being done cooperatively with other studies (especially Groundwater, 7.5, and Riparian Vegetation, 11.6). Furthermore, several adjustments in the schedule, scope, and methods are in a grey area between modifications and variances. These are discussed by sub-element of Objective 6 below and include: (1) introduction of new RVT (Rapid Vegetation Transect) sampling method for acquiring vegetation-groundwater paired sites for constructing vegetation-hydrology response curves; (2) moving groundwater wells outside of vegetation plots in some cases to avoid trampling; (3) likely less use of 2-D groundwater models and more use of observed and interpolated simple gradients and zones of river- or upland groundwater influence; and (4) less emphasis on evapotranspiration field work to parameterize the RIP-ET package for MODFLOW groundwater modeling. MODFLOW is the USGS's three-dimensional (3D) finite-difference groundwater model. In general, NMFS concurs with these decisions. They were all discussed at the Technical Working Group meetings to some extent. Suggestions for scaling back on evaporation-transpiration field work came as much from technical reviews as from the investigators. NMFS supports this decision based on the perspective that detailed variation in transpiration is not likely to be relatively important in the Susitna Valley region because it is not a precipitation limited region. The NMFS continues to have concerns about how well groundwater information will be able to drive vegetation distribution, especially with respect to scaling-up from focus areas and in predicting responses to Project alternatives that produce altered shallow aquifer water levels.

There are five sub-elements in Objective 6 work: (1) Stable Isotope Analyses, (2) Characterization of Rooting Depths, (3) Groundwater/Surfacewater and Riparian Vegetation Modeling, (4) Plant Transpiration; and (5) Riparian Plant-Frequency Response Curves.

Stable Isotope Analyses (ISR Section 4.6.2.1)

Investigating potential water sources for dominant woody and herbaceous species (i.e., precipitation, surface water from main and off channel areas, offsite groundwater sources) by stable isotope analysis is a sophisticated technique, although it may not directly produce a prediction of altered plant composition. To be most useful, plant xylem water should be collected during times of critical water stress (e.g., extended periods without precipitation and low groundwater levels), as well as times of abundance (e.g., periods of precipitation or high groundwater levels due to high river stage). These periods are not always easily defined in advance, but the June, July, and September sampling periods come close. Reporting the antecedent conditions for precipitation, river stage and groundwater for each sample period will be helpful in evaluating the potential to separate water sources for each sample period.

Following the Technical Working Group meeting to discuss the sampling design for collecting plant xylem water, comments were submitted to AEA and FERC (USFWS, Henszey 2013). Concern was expressed that the end-member mixing analysis (EMMA) proposed to estimate the different water sources used by plants requires n-1 independent tracers to uniquely identify n water sources (Phillips and Gregg 2001, Barthold et al. 2011). Currently there are four potential water sources (n = 4), and only two tracers (Hydrogen and Oxygen isotopes), so at least one additional tracer will be needed to meet the required minimum of three independent tracers to guarantee a unique solution. In addition, the two proposed stable isotope tracers may not be independent, since their isotopic fractionation processes scale each other. Fieldwork has continued using only two tracers. However, substantial insight into water sources may be obtained with only two tracers. Thus, it is not critical to expand analysis to include additional tracers at this point. Analysis of the collected isotope data is needed to explore how much separation of sources in plant water can be obtained without analyzing for additional tracers.

Characterization of Rooting Depths (ISR Section 4.6.2.2)

The root depth of dominant floodplain plants will be characterized by observing exposed roots along riverbanks, in trench excavations, and from soil core samples to determine root mass density. Observing exposed roots along riverbanks and in trench excavations is a generally accepted practice in the scientific community for describing root distribution dating back to at least Weaver (1915, 1919). There are methodological concerns about observations of root density (e.g., importance of non-suberized roots and details of washing roots from cores, Larenroth and Whitman 1971 and Sluiter et al. 2008).

The expanded methodology in ISR 8.6 for sampling soil-water content using reflectometers is good. If diurnal fluctuations in water content are observed (i.e., groundwater withdrawal by transpiration), and the amplitude of the fluctuations diminish with depth in the soil profile, these data may provide valuable insights into the effective rooting depth of floodplain plants.

A substantial amount of root depth data has been collected and more sampling is proposed. However, the utility of that data needs to be considered before embarking on substantially more field data collection. Some of the original motivation for collecting rooting depth data was its importance as a component of the RIP-ET (Baird and Maddock 2005) module for MODFLOW (Harbaugh 2005, Baird and Maddock 2005) groundwater modeling. It is currently unclear that this module will be needed or implemented in the Groundwater Study (7.5).

Groundwater/Surfacewater and Riparian Vegetation Modeling (ISR Section 4.6.2.3)

There are two parts of this work. The first is to develop the RIP-ET module of MODFLOW in collaboration with the Groundwater Study 7.5 using data on rooting depths, plant transpiration, groundwater levels, leaf area, and weather observations. A considerable amount of uncertainty has developed about how widely MODFLOW will be utilized and whether the RIP-ET component will be used as a part of MODFLOW applications. RIP-ET was developed for arid and semi-arid regions where rivers are often strongly “losing,” few trees and very low leaf areas are common away from the immediate vicinity of a river, precipitation is low, and potential evapotranspiration is high. Few of those conditions hold for the Susitna and vegetation-driven variation in ET may thus be considerably less important than in the locations where RIP-ET is most commonly used.

The second part of this work is the development of a data set of vegetation (collected in collaboration with Study 11.6) with concomitant surface water and groundwater conditions (produced by a combination of surface water and groundwater models, interpolation, and direct observation). The Rapid Vegetation Transect (RVT) vegetation sampling procedure was proposed in the 8.6 Study Implementation Report of 2015 to facilitate obtaining sufficient vegetation-hydrology replications. Additionally groundwater conditions at vegetation sampling locations will be obtained by a combination of direct well measurements, surface water observations of exposed groundwater, interpolation, and groundwater modeling. This seems likely to work for examining the current distribution of vegetation across sampled plots. It is less clear how well future conditions at other locations and under Project alternatives will be predicted with this approach to groundwater.

Plant Transpiration (ISR Section 4.6.2.4)

Two methods are used to characterize plant transpiration: (1) continuous measurements of sap-flow velocity for woody species, and (2) periodic direct stomatal conductance from the leaves of herbaceous and small-shrub species. Both methods are sophisticated and should provide valuable insight into the transpiration process of floodplain plants along the Susitna River. The continuous sap-flow measurements for woody species will be especially valuable, since they should help to determine how these species respond to various water sources over the course of the growing season (e.g., precipitation events and water-table flux). The periodic direct stomatal conductance measurements will also provide valuable insight, but their value will likely be dependent upon collecting sufficient periodic data to observe diurnal and seasonal trends as well as response to critical events (e.g., water table extremes, and precipitation events).

Riparian Plant-Frequency Response Curves (ISR Section 4.6.3)

This study component will develop quantitative relationships for dominant floodplain plant species and communities as determined by the Groundwater/Surfacewater hydroregime. It will be valuable to include not only the deeper-rooted forest and shrub communities, but also the dominant shallower-rooted herbaceous communities. The shallower-rooted plant species and communities are likely to be more sensitive to regulated Project flows than the deeper-rooted species and communities.

There are numerous details of this analysis worthy of discussion, such as, what summary statistics of surface water and groundwater hydrology are appropriate, what resolution of groundwater levels is necessary, what forms of response curves should be considered (Henszey et al. 2004), how to deal with time since last disturbance and changes in hydraulic position from accretion, and how many observations of different vegetation and hydrology conditions are needed. Introduction of the RVT sampling protocol with less intensive use of observation wells should help obtain adequate sample size. The biggest concern is how to use vegetation-response curves that depend on predicting hydrology at unsampled locations (scaling up) or under new conditions (post-Project). Reasonable capabilities for doing this with open-water surface water are available. Parallel capabilities for ice-covered surface water and groundwater are less certain to be available.

Objective 7: *Floodplain Vegetation Modeling Synthesis and Project Scaling.*

The proposed approach is sophisticated and ambitious. It has potential for providing excellent information for comparing alternatives at multiple scales. However, it depends on results of several other studies and a number of predictive models that are not yet built. As noted above, the aspects most likely to be limiting in both scaling up from focus areas and in predicting Project impacts are (1) groundwater regimes, and (2) physical disturbance from ice.

Modification G-1: NMFS recommends conducting a careful analysis of the current data to determine which lines of investigation should be called complete and which should be pursued further.

The study delay actually provides an opportunity to greatly improve/expand the vegetation studies because the time span is now longer so growth trends will be easier to see.

The study was commenced as provided for in the approved study plan; however the huge snowpack in the 2012/2013 winter led to anomalous groundwater levels and growing conditions (environmental conditions) during the 2013 summer. Re-measuring the vegetation plots a few years after establishment would greatly increase the value of the study.

Modification G-2: NMFS recommends integrating the Riparian Instream flow with other studies specifically 6.6 Fluvial Geomorphology Modeling and 7.6 Ice Processes.

Riparian Vegetation works in tandem with geomorphic processes, ice processes and the existence of high flow events to control whether side sloughs and upland sloughs continue to provide juvenile fish habitat.

This modification will be best established through a new study on Model Integration. NMFS has included a New Study Request in a separate enclosure.

Summary Comments

Study plan variances and conformance are identified in ISR and SIR 8.6. The most important modifications apply to future work and consist of (1) a reduced emphasis on transpiration measurement and modeling, and (2) modified vegetation-groundwater sampling for the purposes of quantifying vegetation-response curves. Although there are some potential limitations associated with both, they do seem generally reasonable and efficient. NMFS concurs with the reduction in transpiration measurements to (1) stomal conductance in 2013; and (2) sap flow in 2013 (partial) and 2014 (full). NMFS also concurs with the modification of paired vegetation-hydrology samples to include the Rapid Vegetation Transect approach and more use of groundwater transects, recognizing that there is some potential decrease in accuracy in order to achieve a reasonably large sample size.

Our two most important concerns and recommendations at this point are (1) using analysis and understanding based on work already completed to inform plans for the second phase of field work; and (2) how to use relations between vegetation and physical conditions of groundwater and ice scour.

The interruption in the original planned schedule due to funding issues offers the opportunity to adjust any new work based on careful analysis of results to date and increased understanding of how the system operates. With further analysis some objectives, such as the seedling establishment study, might reasonably be considered to be completed as originally planned. Additional vegetation-hydrology sampling is critical to establishing vegetation-response curves and thus for estimating potential Project effects. Increased understanding from the study to date suggests other work (frequency distribution of ice scar intensity) may call for more than originally planned effort, whereas less effort may be appropriate for other aspects (e.g., measurement of transpiration, implementation and calibration of RIP-ET, and maybe isotopic definition of water sources and measurement of rooting depths). The main point is that analysis should be the next step.

Depth to groundwater and the time since successional resets caused by ice scour may be very strong determinants of riparian vegetation along the Susitna River. Observations on existing ice scars and groundwater near or between wells will support a reasonable analysis of the relationships between these variables and current vegetation. However, using these relations to scale up from focus areas or to predict post-Project vegetation will require models to predict these physical variables. Some of these issues have been acknowledged and discussed with respect to groundwater in a recent Technical Memorandum (Geo-Watersheds Scientific and R2 Resource Consultants, Inc. 2014). However, there is considerable uncertainty about whether the ice processes and groundwater studies will be able to generate physical predictions well enough to support vegetation predictions.

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9.5 Fish Distribution and Abundance in the Upper Susitna River

ISR Review and Study Modifications

Study Objectives

The objectives of the Upper River Fish Distribution and Abundance (FDA) Study identified in the Federal Energy Regulatory Commission (FERC) study plan determination (April 1, 2013) include:

1. Describe the seasonal distribution, relative abundance (as determined by catch per unit effort [CPUE], fish density, and counts), and fish-habitat associations of resident fish, juvenile anadromous salmonids, and the freshwater life stages of non-salmon anadromous species.
2. Describe seasonal movements of juvenile salmonids and selected fish species such as rainbow trout, Dolly Varden, Humpback Whitefish, Round Whitefish, Northern Pike, Pacific Lamprey, Arctic Grayling, and Burbot within the hydrologic zone of influence upstream of the project by:
3. Documenting the timing of downstream movement and catch using outmigrant traps;
4. Describing seasonal movements using biotelemetry (PIT and radio-tags); and
5. Describing juvenile Chinook Salmon movements.
6. Characterize the seasonal age class structure, growth, and condition of juvenile anadromous and resident fish by habitat type.
7. Determine whether Dolly Varden and Humpback Whitefish residing in the Upper River exhibit anadromous or resident life histories.
8. Determine baseline metal concentrations in fish tissues for resident fish species in the mainstem Susitna River.
9. Document the seasonal distribution, relative abundance, and habitat associations of invasive species (Northern Pike).
10. Collect tissue samples to support Study 9.14 (fish genetics).

National Marine Fisheries Service (NMFS) Study Modifications

Results from the Upper River studies have been compiled in two reports (ISR 9.5 2014 and SIR 9.5 2015).

Three fundamental elements are still needed to fully understand, evaluate, and apply Study 9.5 results. First, Alaska Energy Authority (AEA) must describe the basic process of how the results of the study will be used to estimate project effects on fish populations, and provide statements about what is an acceptable level of accuracy and precision. Second, data collected in all sampling activities need to be made accessible and fully documented. And third, the data should be appropriately summarized and interpreted and statistical methods used in this process should be fully documented. Without these fundamental components, the study completion and documentation remains incomplete.

Although sampling was conducted over a three-year period (2012-2014), only a one year's sampling program was partially completed and results somewhat compromised by unknown interannual effects. NMFS recommends a minimum of two years of data collection be completed and results evaluated to determine if study objectives, including stated levels of precision, have been met. NMFS has consistently recommended five years of study to understand interannual variation in physical and biological parameters. Analysis of the two years of research may well result in recommendations for additional years of studies.

Many study components of Study 9.5 remain incomplete or not attempted at all. These include a mark-recapture study to estimate rotary trap efficiency that was not conducted; association of movement patterns in relation to water conditions (discharge, temperature, and turbidity) that was not summarized; collection of tissue samples for mercury and other baseline metals that was below goal (and only mercury concentrations were measured); and only opportunistic fish stranding and trapping data were collected and not analyzed. The impact of these omissions has yet to be evaluated.

The objectives of the FDA study were not met through implementation of the first study year field methods (2013 and 2014) and data analyses as described within the Initial Study Report (ISR) and associated technical memoranda. The study plan was not implemented as modified by the FERC study plan determination. Our review identified inconsistency between the revised study plan (RSP) and the implementation plan, including inconsistent sampling methods or sampling effort among sampling locations compromise the data and complicate analysis. Further, the first year of sampling provided an opportunity to evaluate the appropriateness of the approved methods and their modifications. We identify opportunities to improve the methodology and increase the likelihood of meeting the approved study's goals and objective

Therefore, we recommend:

1. The FERC modify the approved study plan as outlined below to improve the methods used and achieve the goals and objectives of the approved study;
2. AEA complete two years of studies implementing the methods as described within the FERC approved study plan with the modifications outlined below; and
3. Completing studies with consistent methods for selecting mainstem sampling locations and fish collection methods.

We recommend the FERC approved study methods be conducted as required and study modifications incorporated due to studies not being conducted as provided for in the FERC approved study plan 18 CFR 5.15(d) and the inadequacy of the approved methods. Support for these requested study modifications is included under the applicable study objective.

1. Sampling of fish distribution and abundance should be geographically expanded to include the mainstem and tributaries upstream of the inundation zone. (Objective 1 & 2)
2. To understand the timing of out migrating juvenile Chinook, one downstream screw trap should be place at the head of the reservoirs and a second at the proposed dam location and these should be operated during open water for two seasons. (Objective 2)

3. FDA studies in the main and side channel should be modified to include methods in addition to boat electroshocking such as baited minnow traps and backpack electroshocking along the adjacent bank to capture juvenile salmon. (Objective 1)
4. The fish distribution and habitat association sampling should be modified to use the Proposed Study Plan and Revised Study Plan proposed site selection method, consistent with our comments (11/14/2012 & 3/18/2013). Fish distribution and habitat association in the mainstem and off channel habitat should be conducted using systematic-random selection of 10 or more replicate sample units within each macrohabitat. (Objective 1)
5. Tributary mouth sampling unit selection should be consistent with other level 3 macrohabitats. Sample unit length should be 200 meters and not limited to visually clear water. (Objective 1)
6. Macrohabitats should be sampled as required in the study plan determination. All sampling units of side sloughs, upland sloughs and tributary mouths should be 200 meters long. We further recommend the study be modified to include subsampling units in main and side channel microhabitats of 200 meters of shoreline using baited minnow traps and backpack electrofishing for juvenile salmonids. (Objective 1)
7. Tributary sampling should be conducted as required in the FERC Study plan determination. Sampling units should not be arbitrarily reduced in length. We recommend the approved sampling methodology be modified to include 200, 400 and 800 meter sampling units and occur in 25% of the available sampling units in each tributary as described in the FDA implementation plan for both distribution and relative abundance. (Objective 1)
8. FDA study should be modified to include sampled during the spring (May and June) as proposed by AEA and supported by our comments (3/18/2013). (Objective 1)
9. The study plan should include a description of the data analysis such that a rigorous comparison can be made across species, habitat and seasonally. (Objective 1)
10. NMFS recommends sampling a minimum of 20 baited minnow traps fished for 20 to 24 hours for every 200 m of sampling unit length to document the seasonal distribution and relative abundance of juvenile Chinook and Coho Salmon. (Objective 1)
11. The study plan should be modified such that rotary screw traps initially placed in Oshenta and Kosina tributaries are moved to mainstem locations to better assess movement of downstream migrants. (Objective 2)
12. Assess the migration of juvenile Chinook from Kosina Creek and Oshetna River into the Susitna downstream from the confluence through monthly sampling. (Objective 2)
13. Fish biomentrics should be modified to weigh the first 100 of each species on each sampling date at each sampling location to the nearest 0.1 gram. (Objective 3)

Review by Objective

Objective 1: *Fish Distribution, Abundance and Habitat Associations (Modifications 1, 4–10)*

Geographic Scope

Modification 1: NMFS recommends the sampling of fish distribution and abundance be modified to include the mainstem and tributaries upstream of the inundation zone.

The scope of the study does not survey the mainstem or tributaries above the proposed project impoundment. Adult and juvenile salmon have been observed above the proposed reservoir (ISR 9.7), tributaries above the reservoir could provide salmon spawning and rearing habitat and the proposed project would influence fish passage into the Susitna River and tributaries above the reservoir. The approved Upper River FDA study was developed to document existing conditions within areas that would potentially be altered directly, indirectly, or cumulatively by the proposed project. Upper River sampling methodology was proposed for mainstem and tributary locations that were within, or discharged to, the proposed reservoir inundation zone up to 3,000 ft elevation. However, the major contributor to the proposed reservoir, the Susitna River, was not included within the proposed studies. Tributaries that discharge into the Susitna River upstream of the reservoir, primarily the Tyone River, Maclaren River, and Clearwater Creek, were not include within the proposed study boundaries even though they are well below the 3000 ft elevation line used as the upper boundary for other tributaries. The adult salmon escapement studies (ISR 9.7) have documented the movement of Chinook Salmon into the headwaters of the Susitna River. An accurate description of the current distribution of anadromous fish species and factors that may influence the evaluation of fish passage alternatives is required to determine the need for fish passage protection measures for anadromous fish species, and to inform the design of fish passage facilities. The distribution of anadromous salmon above the proposed project impoundment needs to be document in order to evaluate potential project related impacts. Expanding the geographic zone will address Objective 1 (Fish Distribution, Abundance and Habitat Association) of study 9.5, Study of FDA in the Upper Susitna River.

We now have good information proving salmon presences above the dam site which we did not have when the study plan was written. This new information justifies the modification.

Fish Distribution and Habitat Association Sampling Methodology

Modification 2: NMFS recommends the fish distribution and habitat association sampling be modified to use the Proposed Study Plan and Revised Study Plan proposed site selection method, consistent with our comments (11/14/2012 & 3/18/2013). This method included using systematic-random selection of 10 or more replicate sampling units per macrohabitat. The FDA Implementation Plan (FDAIP) altered this to 30 total systematic transects in the Upper Susitna. Finally NMFS recommends again that in the upper Susitna, three macrohabitats (main channel, split main, multiple split main) are treated as one and called simply “main channel”. This eliminates 20 sampling locations but still leaves 50 sampling units (10 each in main channel, side channel, side slough, upland slough and tributary mouth macrohabitats).

The mainstem habitat sampling approach of the FDA Implementation Plan using systematic transects inadequately represents the Upper River main channel and off-channel fish distribution and habitat association. Only one side channel, one side slough, three tributary mouth/plumes, and no upland sloughs sampled were sampled (ISR Part A, Table 4.1-4) in 46 miles of river. Relative abundance surveys only sampled four main channels, one side channel, and one tributary mouth/plume. Without replication the data cannot be extrapolated to other areas and cannot be considered representative of the Upper River.

The sampling methodology reported in the 2014–2015 Study Implementation Report (SIR) was incomplete and inconsistent with the FERC approved study plan. Methods for site selection were changed in AEAs FDA Implementation Plan to select sites crossed by only 20 (reduced from 30) systematically placed transects. AEA did not sample all transects as proposed within the FDA Implementation Plan, and the sampling approach did not provide adequate replication of macrohabitats in the 2013 or 2014 sampling seasons. The SIR states that six side sloughs and six upland sloughs were sampled. However, AEA only sampled four upland sloughs, with two sampling units each in two sloughs (SIR, Figure A4). In one of the sampled sloughs, sampling units P90 and P94 were 120 meters (SIR, Table 4.3-4) instead of sampling the entire 240 m sampling reach as one sample site as provided for in the approved plan.

This sampling effort does not meet the minimal requirements of the FERC approved study plan and should be considered insufficient to describe fish distribution, relative abundance and habitat association for the Upper River segment of the Susitna River. Further, we still maintain the FERC approved FDAIP methods are inadequate to meet our requested study objectives. Therefore, we request FERC reconsider our RSP comments (3/18/2013) regarding mainstem site selection.

Tributary Mouth Sampling

Modification 3: NMFS recommends sampling entire tributary mouths as a macrohabitats at the confluence of tributaries and the Susitna River or its side channels. Sampling in this macrohabitat should not be limited to clear water plumes based on visual estimates of clarity. Sampling within tributary mouths should include the portion of the tributary influenced by the mainstem (zone of hydraulic influence) and 200 m downstream whether or not a clearwater plume is visible.

FERC's study plan determination recommended that clearwater plumes be classified at level 4 (dividing main channel habitat into pool, riffle, run and rapid mesohabitats) and defined tributary mouth sampling units to extend 200 m downstream. AEA did not sample these entire tributary mouth sampling units but selected to sample clearwater plumes independent from tributary mouths. AEA, therefore, did not implement the FERC approved study plan. We recommend FERC require AEA to conduct the study as required.

AEA's selection of clearwater plumes as a unique sampling unit disassociates this habitat feature from the associated tributary. As such, the completed studies are inconsistent with how this habitat feature is included. There are instances in which only the clearwater plume was sampled verses the tributary mouth and not the mainstem habitat downstream from the tributary mouth. Tributary mouths are the level 3 classification type and are clearly identifiable during all seasons; they should not be refined in the field, based solely on one day's visual observations. Biotic (invertebrates) and abiotic (chemistry, water quality, temperature, etc) characteristics will be different between the mainstem downstream from a tributary mouth and should be sampled as complete units.

Scope of Sampling

Modification 4: NMFS recommends sampling be conducted over the area described in the FERC study determination. All sampling units of side sloughs, upland sloughs and tributary mouths should be 200 meters long. Sampling within upland and side sloughs should begin at the confluence with the mainstem, include the mixing zone of turbid and clear water, when present, and extend upstream into the slough. For main channel and side channel sampling locations boat electrofishing and set or drift nets should effectively sample the entire 500 m sampling unit. We further recommend modifying this study to include subsampling units of 200 m of shoreline using baited minnow traps and backpack electrofishing to sample for juvenile salmonids and resident fish species as proposed in our RSP comments (03/18/2013) and as proposed by AEA.

The FERC approved study plan determination clearly defined sampling unit areas for the primary macrohabitats based upon accepted scientific practices. The study plan determination also defined the locations where sampling sites should be selected in upland sloughs and side sloughs to capture the confluence of those habitat types with the mainstem and tributary mouths. This determination recognized unique habitats that provide characteristics representing the transition between main channel and off-channel habitats. AEA did not sample these areas or sample entire sampling units as required. The data demonstrated that reduced sampling unit lengths underestimates community richness and increases the variability of relative abundance estimates (AEA 2014).

Our RSP comments (3/18/2013) recommended that main channel and side channel habitats include sub-sample of nearshore habitat for juvenile species that may not be captured by boat electrofishing and gill drift netting due to shallow depths and nearshore cover. AEA proposed sampling 200 meter lengths of main channel and side channel habitats if boat electrofishing or drift gill netting is not used. We do not support this proposed modification. It will result in different sampling methods being applied to different sampling units and limit the ability to accurately test for differences in fish abundance among main channel sampling and side channel sampling units or off-channel habitats. Sampling smaller main channel and side channel habitats using minnow traps and backpack electrofishing will likely underestimate the distribution and abundance of grayling Dolly Varden, Whitefish, and Burbot whose probability of capture is lower when using these methods in the nearshore zone. Whereas, mainstem sampling using only boat electrofishing and drift nets will underestimate the distribution and abundance of juvenile salmon. Consistently sampling 500 m mainstem habitats by boat electrofishing and drift gill netting and a 200 m sampling nearshore unit with backpacking electrofishing and minnow trapping will apply methods suitable for all target fish species at all sampling locations and comparable measures of fish abundance within and among macrohabitat types.

Tributary Sampling

Modification 5: NMFS recommends fish sampling occur throughout the entire tributary sampling units as required in the FERC study determination, and that sampling units include 25% of the tributary length as proposed. Sampling unit lengths are 200 m, 400 m, or 800 m based on drainage area as described in the FDA implementation plan for fish distribution and abundance.

AEAs proposed study modification (ISR Part C 7.1.2.4) is unclear. Analysis presented in AEA's Black River Technical Memorandum does not support a reduction in tributary sampling area. AEA is not proposing to sample the entire sampling unit, but "apportioning the additional sampling length within existing panels [sampling unit] by increasing the number of replicates of mesohabitats units sampled per panel."

The AEA Technical Memorandum (Appendix A of ISR 9.5), submitted to FERC on December 14, 2014, evaluates whether the failure to implement the FERC approved FDA study plan affected the ability to meet study objectives. The study compared FDA sample results from the Black River collected in 2013 with sample results from longer sampling units in 2014. This analysis was inadequate based on the differences between the sampling designs. Black River sampling in 2013 covered approximately 1.0 km of stream length. This is less than half of the six 400 m sampling units, or 2.4 km required by the study determination. The portion of the Black River sampled in 2014 was greater than in 2013, and was based on target levels of effort proposed by Kirsch et al. (2014), and not the FERC approved study plan. Measures of species richness and electrofishing CPUE for three species from 2013 and 2014 were used to determine if the results from 2013 subsampling would meet study objectives. The study assumed that no other environmental factors, including a September 2012 storm event, affected estimates of species richness or relative abundance in 2013 or 2014. The study comparison did not evaluate the difference between sampling unit used in 2013 or 2014 and the sampling unit lengths described in the FERC approved study plan. With these complicating factors, the evaluation found that the subsampling which occurred in 2013 underestimated the distribution of some species, resulted in lower species richness, and a higher standard error in mean relative abundance. The subsampling in 2013 may; therefore, have missed rarer species in some tributaries including Chinook Salmon or other salmon species, longnose suckers, or Round Whitefish. The higher standard error would reduce the probability of detecting significant differences in relative abundance among habitats.

The ISR proposed modification is to sample stream lengths based on the recommendations by Kirsch et al. (2014) and sample units as required in the FERC approved study plan. In all the sampled tributaries (except for the Black River), modified sampling lengths proposed in the ISR for future sampling are up to 5 km less than the tributary sampling lengths in the FERC approved study plan (Table 1). The Technical Memorandum demonstrates that the subsampling conducted in 2013 is insufficient to meet study objectives; however, it does not evaluate whether targets proposed as a study modification, which are a reduction from sampling lengths in the FERC approved study plan, are adequate to meet study objectives.

Table 1. Comparison between RSP sample lengths as determined based on sampling occurring in 25% of the available 200, 400, or 800 m sample units within each tributary to length sampled in 2013 and sampling lengths based on AEAs study modifications. The asterisks are for streams where the total number of available sampling units was not known, and sampling length was based on the minimum of 3 sampling units in each stream. The difference between the RSP and 2013 sampling shows that sampling was well below the effort described in the FERC approved study plan. The difference between 2014 and the RSP indicate the reduction in sampling length

for each stream if AEAs proposed study modification is approved. UT is unnamed tributary, numbers in parentheses are project river mile. Data is from AEA Table 2.3-1.

Tributary	RSP Sample Length (m)	Length Sampled 2013 (m)	Difference (2013-RSP)	AEA Proposed 2014 Lengths (m)	Difference (2014-RSP)
Oshetna (235.1)	10400	2604	-7796	5026	-5374
Black River	2400	1050	-1350	3178	778
Goose Creek (232.8)	4050	3107	-943	1704	-2346
Kosina Creek	4800	1000	-3800	4522	-278
Tsisi Creek	2300	980	-1320	1988	-312
Watana Creek	6000	2561	-3439	1554	-4446
Watana Trib	3350	1459	-1891	1330	-2020
Unnamed 194.8	3200	300	-2900	476	-2724
Jay Creek	840*	324	-516	560	-280
UT (206.3)	414*	0	-414	276	-138
UT (204.5)	270*	0	-270	180	-90
UT (197.7)	426*	0	-426	284	-142
Deadman Cr (189.4)	1704*	0	-1704	1136	-568

Spring Sampling for Distribution and Abundance

Modification 6: NMFS recommends spring sampling be conducted as proposed in the RSP for fish distribution and abundance in May or early June (in addition to the two summer and a fall sampling events) at all sampling locations.

AEAs PSP proposed monthly, year-round monthly sampling for FDA. The RSP does not provide a sampling schedule but references the FDA Implementation Plan. The FDA Implementation Plan (page 7) states the sampling will be conducted every other month May through October. We recommended sampling once in early spring following ice breakup (May or early June), twice during the summer (July – August) and in the fall, mid-September to early October. FERC supported our proposal for spring sampling. FERC recommended two summer sampling events but did not adjust the spring or fall sampling schedule proposed by AEA.

FERC also incorrectly stated that AEA was proposing to conduct biweekly early life history studies in the Upper River. Early life history sampling was not proposed by AEA for the Upper River and is not applicable to this study.

AEA did not conduct spring sampling at all sampling locations as proposed within the FDA Implementation Plan. Instead AEA conducted limited spring early life history sampling in select tributaries without addressing FERCs misunderstanding of the proposed sampling plan. Therefore, no spring data are available to identify whether resident fish moved into tributaries or overwintered in tributaries or the mainstem. In addition, since sampling was not conducted in mainstem sites in the spring, it is not known whether juvenile Chinook Salmon moved from spawning streams to mainstem overwintering locations as previously documented previously for middle river Chinook (e.g. juveniles migrating from the Indian River to the mainstem).

Completion of Two Sampling Years as Required

NMFS recommends a minimum of two years of data collection needs to be completed as described in the FERC approved study plans.

Two years of data collection is insufficient to adequately capture the relative abundance and distribution of resident and anadromous fish and NMFS has consistently recommended 5 years of study. However, at a minimum, two years of sampling must be conducted as required in the FERC approved study plan. The distribution of juvenile Chinook Salmon can be underestimated when studies are conducted during years of low returns. The annual variability in overwinter conditions, flood flows, spawning success, and recruitment influence fish distribution and habitat associations. Annual variability may result in a misunderstanding of current conditions and the inaccurate development of mitigation measures.

Data Analysis

Modification 7**:** NMFS recommends the study plan be expanded to include a description of how the various data will be turned into quantitative estimates so that rigorous comparisons can be made across species, river habitat types and time.

The sampling plan should be reevaluated so that there is a tight linkage between the sampling design and the estimates and statistical inferences that will be drawn from the data. Estimates should be presented with appropriate measures of sampling error (confidence intervals or standard errors). NMFS recommends that statistical tests are used to determine if differences in mean relative abundance measures are significantly different among habitat classifications at all classification levels 1 through 3. See NMFS comments on AEA Study 9.6 for information supporting this study modification.

Fish Sampling Methods

Modification 8: NMFS recommends sampling a minimum of 20 baited minnow traps fished for 20 to 24 hours for every 200 m of sampling unit length to document the seasonal distribution and relative abundance of juvenile Chinook and Coho Salmon. Fyke nets and hoop traps, and beach seines can be used to augment minnow trapping and electrofishing for fish distribution, but should not be used to derive estimates of relative abundance.

The generally accepted scientific practice is to apply consistent methods and effort among sampling units (mainstem macrohabitats and tributary sampling reaches) to properly compare relative abundance by species and age class among habitat classification types. This supports testing for statistical differences in fish abundance or community composition among habitat types or trends in fish metrics due to differences in physical or chemical characteristics. This is a critical step to meet the approved study objective. We found no record of a published scientific study where relative abundance using different sampling methods was compared among sampling sites (i.e. electrofishing at one site compared to fyke nets or minnow traps at another).

The ISR describes fish collection methods that varied in sampling area, sampling methods, and sampling effort. Fish data were collected at one location or sampling date using electrofishing; a fyke net data during another sampling location; and minnow trap data at a third. Electrofishing time varied among sampling locations from seconds up to 20 minutes. Units of metrics of relative abundance or community composition were different and not comparable among sites (i.e. catch/time/area, catch/trap/area, or catch/net/area). The data cannot be compared among sites and, therefore, the study goal of evaluating distribution and habitat association cannot be achieved.

Baited minnow traps are an effective method for capturing juvenile Chinook and Coho Salmon (see NMFS comments (3/18/2013). Multiple traps can be set in all available habitats (i.e. depth, velocity, substrate, cover) and result in a reduced variability in catch data. Minnow trapping also is not disruptive and should not affect the catchability of other sampling methods and is effective in areas of dense cover (Bryant 2002). This method can be consistently applied within all sampling units.

Lastly, all sampling locations, sample unit length and area, sampling date, sampling methods, effort for each method (electrofishing time, number of seine hauls, number of minnow traps and hours fished, snorkel time, number of fyke nets and hours fished), macrohabitat classification, and length and area of each mesohabitat within the sampling unit, be recorded and reported. A consistent methodology with statistically sound data and well documented methodology is the generally accepted scientific practice.

Modification 9: FDA studies in the main and side channel should be modified to include methods in addition to boat electroshocking such as baited minnow traps and backpack electroshocking along the adjacent bank to capture juvenile salmon. (Objective 1)

The current methods assume there are no juvenile fish living in the main stem margins and therefore do not worry about the fact that boat electro-shocking is likely to miss juveniles on the rivers edge. Exiting methods will not completely meet Objective 1.

Objective 2: *Seasonal Movement of Juvenile Salmonids*

Geographic Scope

Modification 10: NMFS recommends that sampling of fish distribution and abundance should be geographically expanded to include the mainstem and tributaries upstream of the inundation zone. The currently approved study plan does not survey the mainstem or tributaries above the proposed project impoundment. Adult salmon have been observed above the proposed reservoir (ISR 9.7), tributaries above the reservoir could provide salmon spawning and rearing habitat and the proposed project can influence fish passage into the Susitna River and tributaries above the reservoir. The movement behavior of anadromous salmon above the proposed project impoundment needs to be document in order to evaluate potential project related impacts on migration behavior. Expanding the geographic zone will address Objective 2 (seasonal movements of juvenile salmonids) of study 9.5, Study of FDA in the Upper Susitna River.

The approved Upper River FDA study was developed to document existing conditions within areas that potentially would be altered by the proposed project. Upper River sampling was proposed for mainstem and tributary locations that were within or discharged to the proposed reservoir inundation zone up to 3,000 ft elevation. However, the major tributary to the reservoir, the Susitna River, was not included within the proposed studies. Tributaries that discharge into the Susitna River upstream of the reservoir, primarily the Tyone River, Maclaren River, and Clearwater Creek, were not included within the proposed study boundaries. A clear and accurate description of the movement behavior of anadromous fish species and factors that may influence the evaluation of fish passage alternatives is required to determine the need for fish passage protection measures for anadromous fish species, and to inform the design of fish passage facilities.

Adult salmon escapement studies (ISR 9.7) have documented the movement of Chinook Salmon into the headwaters of the Susitna River. AEA contractors have stated during fish passage Technical Team meetings that large 2+ Chinook salmon have been captured in Upper River tributaries. Since Chinook Salmon are known to have a 1 year freshwater residency, these fish were more likely Coho Salmon (see our Study 9.6 comments (9/22/14) for a discussion on Fish Identification errors). The Tyone River, Maclaren River and Clearwater Creek all appear to provide abundant salmon spawning and rearing habitat (see ADFG Enhancement Report). With salmon identified above the proposed inundated area as well as spawning habitat, there is a need to understand the out migration behavior of these species. The requested study modification will inform the decision making process related to project impacts and downstream fish passage.

Deployment of Downstream Migrant Traps

Modification 11: NMFS recommends a downstream migrant screw trap at the proposed dam location and an additional one at the reservoir head be installed and operated for a minimum of two years during the open water seasons as required in the FERC determination.

AEA did not install and operate a downstream migrant trap (screw trap) near the proposed dam location as required by the FERC approved study plan. Sampling downstream migrating fish at the proposed dam location will determine which fish species may require downstream passage protection at the dam and the timing of migrating salmon and resident fish. For example, juvenile salmon from Upper River spawning tributaries may migrate to the Upper River mainstem for summer rearing and overwintering as has been documented for Middle River tributaries. Juvenile Chinook Salmon also have been shown to migrate large distances down the mainstem Susitna River after leaving tributaries. AEA winter studies have documented juvenile Chinook Salmon migrating from the Indian River (PRM 142) to Whiskers Creek (PRM 104) to overwinter. Juvenile salmon from the Oshetna, Kosina, or other Upper River tributaries may migrate past the dam site for summer rearing or overwintering in the Middle or Lower Susitna River.

Understanding the species and timing of downstream migration is critical to assessing potential project related impacts and evaluating passage alternatives.

Determining the migration pattern of salmonids and the environmental factors influencing migration is not likely to be accomplished during one or two years of study. We recommend at least 5 years of data collection. We will reevaluate needs for additional data collection upon review of the first two full years of data.

Placement of Rotary Screw Traps on Upper River Tributaries

Modification 12: NMFS recommends that FERC reconsider NMFS's RSP comments (3/18/2013) which recommended that rotary screw traps be placed in the main channel just downstream from the mouth of the Oshetna and Kosina Creeks to capture fish migrating from these tributaries and fish migrating downstream within the Susitna River mainstem. The screw traps at the mouth of the Oshetna and Kosina Creeks should be operated 7 days a week to document the movement of juvenile Chinook Salmon to mainstem rearing and overwintering habitats. AEA should conduct the population estimates and assess the efficiency of the migrant trap as described within the FERC approved study plan.

Our RSP comments (3/18/2013) recommended placing screw traps within the mainstem Susitna River downstream from the Oshetna and Kosina Creeks. This placement and duration of sampling would capture those fish moving out of tributaries and into the mainstem Susitna River, rather that fish moving within a tributary. AEAs study plan recommended placement within tributaries rather than the mainstem based on hydrologic conditions. Following the 2013 sampling season, AEA has requested a study modification to move the Oshetna screw trap to the Susitna River and replace the Kosina Creek trap with fyke nets. We support the screw trap be relocated to the Susitna River mainstem downstream from the confluence with the Oshetna Creek. We do not support AEAs modification to replace screw traps with fyke nets in Kosina Creek.

Fyke nets at Kosina Creek documented the movement of 2 age-0 Chinook juveniles moving into the mainstem in late June and early July and one 46 mm Chinook (identified as Parr in the AEA database) was captured at PRM 200.8 during this same time period. This also suggests that age-0 Chinook Salmon are moving to the mainstem Susitna for rearing and overwintering. However, the sample size is too small. Operation of the screw traps 7 days a week, and determining the efficiency of rotary screw traps, will provide a measure of the migration timing of age-0 Chinook from tributaries to the mainstem.

AEA has not tested the efficiency of using a fyke net instead of screw traps. We are concerned with the use of fyke nets set for 20 to 24 hours at a time. It is our experience that maintaining ¼ mesh net in flowing water for this duration is difficult if not impossible as nets become clogged with debris. While fyke nets may have been effective at catching fish in Kosina Creek as AEA asserts (ISR Part C), AEA did not test the efficiency of these traps or provide a description of trap condition over time. Rotary screw traps were designed to overcome the limitations of maintaining a fine net in flowing water.

AEA did not test the efficiency of the screw traps as required in the study plan determination. AEA should conduct trap efficiency tests as described within the FERC approved study plan for all screw traps. This information is necessary to evaluate the effectiveness of the study methodology at describing the movement patterns of target species and age classes. Rotary screw traps at RM 200.8, and fyke nets downstream from Kosina Creek in 2014 effectively documented smolt migration from trap installation in late May through late June. The rotary screw trap in the Oshetna River was less effective during this time period. This suggests that either the trap is inefficient or that most of the Chinook smolt emigrated from mainstem overwintering locations.

Chinook Juvenile Movement Patterns in Oshetna River and Kosina Creek

Modification 13: NMFS recommends assessing the migration of juvenile Chinook from Kosina Creek and Oshetna River into the Susitna downstream from the confluence through sampling once a month June through September in both the tributaries and directly downstream in the Susitna. We recommend expanding the data collection using differences in the relative abundance of juvenile salmonids in tributaries over time, in addition to screw trap data to determine movement patterns. Based on 2013 results, it does not appear that the PIT tagging study will provide any useful data regarding fish movement patterns or growth rates of juvenile salmonids.

A total of 1,224 PIT tags were implanted (913 Arctic Grayling, 109 Dolly Varden, 98 Round Whitefish, 31 Burbot, and 22 juvenile Chinook Salmon); 42 fish were recaptured/observed; however, no tagged Chinook Salmon were recaptured in 2013. The detection efficiency of PIT tag interrogations systems were not determined as required in the FERC approved study plan.

By PIT tagging fish captured in the rotary screw trap and then releasing them upstream of the trap and PIT tag interrogation system (757 of 1,224 tagged), the results are biased toward fish already in the process of migrating and the actual range of migration timing may be missed because it is delayed by handling or missed by either the first or second downstream movements.

Because PIT tag arrays had to be placed in smaller side channels of Kosina Creek and the Oshetna River, it is impossible to differentiate between movements or presence within the mesohabitat. This is especially confounded in the Oshetna River, where the flow patterns in the side channel selected dropped to levels that would limit fish use. The antenna was moved to a different side channel and then rotated to the main channel when flows also dropped at this site.

ISR Table 5.2-4 provides the number of fish implanted with PIT tags and recaptured. It is unclear how many were not included in values due to “missing implant records, multiple implant records, or inconsistent species identification upon recapture.” For example, the ISR states that an additional 3 Dolly Varden (not included in the tags implanted total) were recaptured (Part A, 5.2.2.2), with no explanation for how many tags were deployed with missing fish metrics.

The results of PIT tagging in tributaries are described as showing movement between split single and complex tributary channels and between complex tributary and split main channels (for Arctic grayling). Rather than this showing a preference between macrohabitat or mesohabitat types (as described in the ISR), it only shows that there is longitudinal movement within or out of the tributaries. The “macrohabitats” described also do not follow the tiered habitat classification system; complex, split, and single main channels are all main channel habitats. Additionally, the majority of tagging and recapture sites were the rotary screw traps or PIT antennas, which bias results to that habitat type and location (i.e. habitats were not equally sampled to show any patterns).

There were not enough recaptures or tag detections to meet study objectives. There were no results for Chinook Salmon movements due to few tagged fish, and no recaptures of tagged individuals. The RSP stated that all juvenile salmon would be tagged yet only 22 of 242 captured Chinook Salmon were tagged in 2013. Only Arctic grayling had enough PIT tagged fish recaptures to provide results for movement between habitats. However, all but one of these recaptures show longitudinal movements within tributaries, upstream of the hydrologic zone of influence (at PIT antennas and rotary screw traps), and the movements are incorrectly described as between macrohabitat types. The macrohabitats described were single, split, and complex tributary channels, all which would be main channels of a tributary according to the tiered habitat classification system.

Our RSP comments recommended that more intensive tributary and mainstem sampling replace the PIT tag study to determine movement patterns of juvenile salmon. We reiterate the need to expand the sampling capacity.

General Comments for Objective 2

Approved Methods Require Modification

The currently approved methods used to document the movement of salmon juveniles were not effective to meet the study objectives of study 9.5. Rotary screw traps in Kosina Creek and the Oshetna River were unable to document the timing of juvenile salmon movement within these stream systems due to low capture efficiency. Juvenile salmon were not detected at PIT tag arrays which could not be effectively deployed in these river systems and required juvenile salmon to enter side channels that were dewatered under some flow conditions. Detection efficiency of PIT tag antennas was not tested as described within the approved sampling plan. We recommend a modification of the PIT tag study and rotary screw trap study to combine tagging and intensive sampling to determine the distribution, habitat associations, and movement patterns of Upper River juvenile Chinook Salmon.

Tributary sampling was not conducted at all selected sampling units, and entire sampling units were not sampled. Tributary sampling units were selected using systematic random methods to determine habitat associations for multiple species, which resulted in multiple sampling units that did not provide habitat conditions likely to support juvenile salmon. Mainstem sampling units selected macrohabitat crossed by randomly selected transects did not adequately sample tributary mouths and off-channel habitats that provide juvenile salmon habitat in 2013 and only a limited number of off-channel habitats were sampled in 2014. Sampling in side sloughs and upland sloughs was not conducted at the mouth of these sloughs as approved within the study plan determination. The mouths of these habitats are more likely to support juvenile salmon migrating down the mainstem Susitna River compared to sites further upstream in sloughs, unless adult salmon are spawning within the slough. For salmon to be present in the upper sections of sloughs, these juvenile salmon would need to migrate up these sloughs or enter side sloughs at the upstream end during breaching flows. Therefore, it is more likely for them to be present at locations closer to the mainstem Susitna River.

A clear and accurate description of the current distribution, habitat association and behavior of anadromous fish species and factors that may influence the evaluation of fish passage alternatives is required to determine the need for fish passage protection measures for anadromous fish species, including flow and project operations control. Study modifications discussed in this section are intended to improve data collection and better inform the decision process.

Clarification of Rotary Screw Trap Details

The RSP, Implementation Plan, and ISR do not state the mesh size of screw trap live boxes. Depending on mesh size emergent fry may not be retained in live boxes. The study methodology should clearly describe features of the screw trap. Mesh size used to construct live boxes should be < 2 mm or ~ 1/8 inch. We want to ensure that juvenile salmon, grayling, and other resident fish that emerge from tributary spawning locations and migrate downstream to the Susitna River are retained within trap live boxes.

Objective 3: *Describe Early Life History of Juvenile Salmonids*

Biometric Sampling Protocols

Modification 14: NMFS recommends the first 100 of each species on each sampling date at each sampling location should be weighed to the nearest 0.1 gram. All fish captured as part of the FDA study should be measured to fork length as required in the study plan determination. Differences in average lengths and weights over time and among habitats can be an indication of differences in growth and habitat quality. Differences in lengths or weights over time and among locations can be analyzed relative to water quality parameters to determine those variables influencing the growth rates of resident fish and juvenile salmonids.

AEA did not implement the sampling plan regarding measuring fish lengths and weights as described within the approved sampling plan. We reiterate the need to obtain fish lengths for all fish and fish weights on a subsample of fish by species, sampling date, and sampling site.

AEAs RSP and FDA Implementation Plan did not clearly specify the number of fish to be measured for length and weight. Section 5.1.5 states that, “each time a gear is sampled, a random sample of 25 individuals per species, life stage, and site will be measured for fork length.” The RSP stated that “in conjunction with objectives 1 and 2, all captured fish will be identified to species, measured to the nearest millimeter (mm) fork length, and weighed to the nearest gram” (Section 9.5.4.3.3). The FERC study determination incorrectly states that all fish would be measured for length and weight stating, “AEA is already proposing to measure the fork length and weight of all captured fish during Upper River sampling.”

It is not clear what methods AEA applied in the field in 2013. No data were provided by AEA in the ISR on fish lengths or weights. We cannot evaluate the effects of the study modification implemented by AEA. The ISR states that AEA randomly measured 25 fish per species and life stage, on each sampling date. It is unclear if fish were only measured during relative abundance surveys or if they were also measured during fish distribution surveys (ISR Part A, Section 4.4). This is considerably different than measuring all fish, or even 25 fish per species per life stage per site as described in the approved sampling plan.

The fork length of all salmonids should be measured in the field as required in the study plan determination. Fork lengths are necessary to estimate age classes based on size frequency distributions. Length data will allow for comparisons among sampling locations, mesohabitats, macrohabitats, tributaries etc., and allow for calculation of growth as a change in length or weight over time.

In collecting weight of fish, AEA measured juvenile salmonids to the nearest gram. Obtaining fish weights to the nearest gram does not provide the precision necessary to evaluate differences in condition factors among sampling locations. Juvenile salmonids may only weigh from 1 to 3 grams; therefore, application of the methods as in 2013 does not provide sufficient precision to meet the study objective. At a minimum, AEA should obtain weights to the nearest 0.1. As most field scales are accurate to this level precision, this effort will require no additional cost or effort.

<u>General Comment for Objective 3</u>

The RSP and FDA Implementation Plan did not propose early life history sampling in the Upper River to characterize the seasonal age class structure, growth, and condition of juvenile anadromous and resident fish by habitat type. AEA conducted early life history sampling in one or two streams instead of conducting spring sampling at all sampling locations as described in the FDA Implementation Plan. The early life history study was developed to determine the movement patters of emergent salmon from Middle River spawning locations (Sockeye, Chum, and Coho). The study was intended to determine when these emergent fry would be subjected to impacts from the modification of mainstem flows due to changing water surface elevations as a result of hydropower operations. For Middle River tributaries, screw traps and PIT tag studies were developed to determine when emergent fry, juveniles, and smolt (all salmon species) migrated to the mainstem. These same methods were applied in Upper River tributaries. It is not clear why AEA conducted early life history studies in Upper River tributaries as these studies were not proposed and are not applicable. In addition, the resource agencies did not have the opportunity to comment on study objectives, sampling locations, sampling frequency, field methods, or data analyses. The limited Upper River early life history tributary sampling implemented by AEA without a study plan should not replace Upper River spring FDA sampling.

Objectives Not Discussed: *Objectives 6, 7 and 8 deal with resident fish so NMFS will not comment.*

NMFS proposes no modifications for Objective 7.

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9.6 Fish Distribution and Abundance in the Middle and Lower Susitna River

ISR Review and Study Modifications

Study Objectives

The objectives of the Lower River Fish Distribution and Abundance (FDA) Study identified in the Federal Energy Regulatory Commission (FERC) study plan determination (April 1, 2013) include:

1. Describe the seasonal distribution, relative abundance (as determined by CPUE, fish density, and counts) and fish habitat associations of juvenile anadromous salmonids, non-salmonid anadromous fishes, and resident fishes.
2. Describe seasonal movements of juvenile salmonids and selected fish species such as rainbow trout, Dolly Varden, Humpback Whitefish, Round Whitefish, Northern Pike, Arctic Lamprey, Arctic Grayling, and Burbot, with emphasis on identifying foraging, spawning, and overwintering habitats within the mainstem of the Susitna River, including:
3. Documenting the timing of downstream movement and catch using outmigrant traps; and
4. Describing seasonal movements using biotelemetry (passive integrated transponder [PIT] and radio-tags).
5. Describe early life history (ELH), timing, and movements of anadromous salmonids, including:
6. Describing emergence timing of salmonids;
7. Determining movement patterns and timing of juvenile salmonids from spawning to rearing habitats;
8. Determining juvenile salmonid diurnal behavior by season; and
9. collecting baseline data to support the stranding and trapping study (i.e., part of Study 8.5, fish and aquatics instream flow).
10. Document winter movements and timing and location of spawning for Burbot, Humpback Whitefish, and Round Whitefish.
11. Document the seasonal age class structure, growth, and condition of juvenile anadromous and resident fish by habitat type.
12. Document the seasonal distribution, relative abundance, and habitat associations of invasive species (Northern Pike).
13. Collect tissue samples from juvenile salmon and opportunistically from all resident and non-salmon anadromous fish to support Study 9.14 (Baseline Fish Genetics).

The objectives of the FDA study were not met through implementation of the first study year field methods (2013 and 2014). The study plan was not implemented as modified by the FERC study plan determination. Our review identified inconsistencies between the revised study plan (RSP) and the implementation plan (3/1/2013), including inconsistent sampling methods or sampling effort among sampling locations which compromise the data and complicate analysis.

The FDA study did not accurately document the distribution or habitat associations of juvenile salmon or resident fish due to problems with habitat classification, sampling site selection and subsampling, fish sampling methods, and fish identification. Further, the first year of sampling provided an opportunity to evaluate the appropriateness of the approved methods and their modifications. National Marine Fisheries Service (NMFS) recommends the following actions be taken to improve the methodology and increase the likelihood of meeting the approved study's goals and objective. We recommend:

1. Alaska Energy Authority (AEA) complete two years of studies implementing the methods as described within the FERC approved study plan with the modifications outlined below; and
2. Complete studies using consistent methods for selecting mainstem sampling locations and sampling fish.

NMFS Study Modifications

We recommend the following study methods and study modifications which are necessary improvements to the approved study methodology be incorporated in future studies so that studies results meet objectives are useful for assessing baseline conditions, assessing project impacts and developing protection, mitigations and enhancement measures to protects fish and wildlife and their habitats. The need for these requested modifications is addressed below.

1. Require that "spring" sampling be conducted in May or early June, within ten days of breakup as feasible, at FDA sampling locations as described within the RSP and FDA Implementation Plan (FDAIP).
2. Classify Middle River macrohabitats as Level 3 macrohabitats and select sampling units sample and report sampling from those units as described within the FERC-approved study plan.
3. Macrohabitat sampling of tributary mouths must be conducted at the confluence with the Susitna River main channel and side channels. (AEA sampled "tributary mouths" based on clear water plumes using visual estimates of water clarity. Tributary mouths are confluences of main and side channels and while clear water plumes are often present at tributary mouths, clear water plums are not in and of themselves tributary mouths.)
4. Mainstem sampling unit selection should be consistent with the selection and sampling of other mainstem Level 3 macrohabitats.
5. Sampling should be conducted within each macrohabitat as described within the FERC study plan determination.
6. Main channel boat electrofishing should be augmented with baited minnow traps and backpack electrofishing to document the seasonal distribution and relative abundance of juvenile Chinook and Coho Salmon. Any time minnow traps are used to determine abundance in a 200 m sampling unit, at least 20 minnow traps should be set for 20-24 hours and the traps should be set about 10 m apart from each other.
7. Reporting should include the following data for sampling locations: sample unit length and area, sampling date, sampling methods, effort for each method (electrofishing time, number of seine hauls, number of minnow traps and hours fished, snorkel time, number of fyke nets and hours fished), and macrohabitat classification.

8. Pre-season field training for identification of salmonids should be provided to the sampling crew. Tissue collection for genetic analyses should be collected from every 10^{th} juvenile salmon sampled to confirm species identification.
9. Transect-based sampling should be replaced with macrohabitat sampling based on macrohabitat classification of a minimum of 10 sampling units each in tributary mouths, side sloughs, upland sloughs, side channels, and main channel macrohabitats (at least 50 total sampling units).
10. The importance of beaver ponds and pond complexes for juvenile salmon summer rearing and overwintering must be determined.
11. Document the Middle and Lower River fish winter distribution, habitat association and abundance.
12. Development of an operational plan that includes the methods used to develop quantitative estimates including a discussion of all model assumptions, target statistical precision and confidence errors to allow for rigorous comparisons across species, river habitat types and sampling dates.
13. Juvenile salmon should be identified to species and species identification should be verified with genetic analysis.
14. A mark-recapture study measure the efficiency of the rotary screw traps should be conducted as proposed in the FDA Implementation Plan
15. Downstream migrant traps (rotary screw traps) should be deployed and operational immediately following breakup and operated throughout the open water season to obtain migration data at the four locations described in the approved study plan.
16. Rotary screw traps should be used to capture PIT tagged fish exiting tributaries.
17. Size frequency age-class distribution should be reported using fork-length (mm) measurements. AEA reported age-class distribution using general classifications of juvenile life stage (e.g., fry, parr, juvenile, and smolt).
18. The PIT tagging study should be conducted as required in the study plan determination, including evaluation of detection efficiency, and be modified such that the data can determine the movement patterns of juvenile salmon from spawning tributaries to the mainstem and off-channel habitats. If this cannot be done, NMFS recommends eliminating the ineffective PIT tagging study and implementing other methods to document juvenile fish migration.
19. Only if the PIT tagging study is improved as recommended, the scope of fish sampling and PIT tagging should be expanded to include Whiskers Creek, Montana Creek, and Indian River.
20. ELH studies should be conducted on sampling dates at Focus Areas as described in the RSP .The study should include minnow traps, fyke nets and hoop trap gear types.
21. Integrate emergence studies with proposed winter sampling at Focus Areas prior to breakup, suspending sampling during breakup, and reinitiating sampling following breakup.
22. Conduct ELH sampling in the Lower River proximal to known Chum, Sockeye, and Coho Salmon spawning locations.
23. Juvenile fish captured as part of the FDA study be measured for fork length as proposed within the RSP and the first 100 of each species on each sampling date at each sampling location should be weighed to the nearest 0.1 gram to document age class structure, growth and fish condition.

Review by Objective

Objective 1: *Distribution and Habitat Association (Modifications 1-14)*

Main Point # 1: NMFS recommends a minimum of two additional years of data collection be completed to fully implement the approved methods with our requested modifications to improve the originally approved study plan.

FDA studies in 2013 and 2014 were not conducted as provided for in the approved plan. Anomalous environmental conditions (fall storms and late breakup) in combination with low 2012 adult salmon returns will result in low numbers of juvenile salmon and influence studies designed to determine the distribution of these species and their habitat preferences.

In addition, low salmon returns in combination with a 100 year storm event in 2012 likely resulted in low abundance of juvenile salmon in 2013 and the winter of 2014. Low juvenile salmon abundance would inhibit accurate documentation of distribution and habitat associations. The September 2012 floods, which followed most salmon spawning, likely reduced the abundance of juvenile salmon in summer 2013 and winter 2013/2014 sampling. Discharge during this storm event was within the top three flows measured in many Susitna River drainage streams including the Talkeetna River and Chulitna Rivers and Montana Creek and Willow Creeks (Curran 2012).

Adult salmon escapement in the Susitna River drainage was well below normal in 2012. Combined with large fall floods in September of 2012, this resulted in low abundance of juvenile salmon in 2013. Ten of the 14 Susitna River tributaries surveyed by the Alaska Department of Fish and Game (ADFG) in 2012 did not meet their 2012 escapement goals (Hayes 2012). For example, salmon escapement into Montana Creek was below 500 fish, less than half of the escapement goal of 1000 and well below peak counts of up to 3000. Escapement into Prairie Creek was less than 1/3 of the goal of 3,000 Chinook Salmon. ADFG closed sport fishing or reduced bag limits throughout the Susitna River drainage during 2012 and 2013 (emergency orders posted online by ADFG).

Low returns and fall floods resulted in reduced distribution and abundance of juvenile salmon in 2013 and the winter of 2014. Juvenile salmon monitoring throughout Mat-Su area streams showed a reduction in the abundance and distribution of fish in 2013 (Ramage et al. 2014). Chinook Salmon juveniles were absent from 5 survey streams where they had previously been observed in each previous sampling year. Juvenile Coho Salmon abundance in Queer Creek in 2013 was the lowest recorded in samples collected since 2008 (Ramage et al. 2014). During the winter of-2013, over 300 juvenile Chinook Salmon from the 2011 cohort were captured in nine Susitna River sloughs During 2014, six juvenile Chinook Salmon were captured from 2012 spawning at a similar number of sampling locations (Davis et al. 2013 and 2015).

Late breakup in 2013 prevented AEA from conducting ELH sampling during May and early June delayed the installation of rotary screw traps.

Main point #2: Field sampling in the first year of study (2013 and 2014) did not implement the approved studies and does not provide study results that address the project objectives or comparable data for subsequent years of study. Anomalous conditions including severe fall storms in 2012, late breakup in 2013 and poor 2012 salmon returns limited study implementation and will likely affect measures of fish abundance and distribution.

Fish sampling was not applied to the total sampling units (200 to 500 m) as provided for in the approved study plan. Sampling units were selected at the macrohabitat level, but was conducted at the mesohabitat (riffle, run, pool) level and macrohabitat values cannot be estimated. Sampling was not conducted at the mouths of side sloughs and upland sloughs as provided for in the approved study plan. Tributary mouths were also not sampled as described in the approved plan. Comparisons of fish abundance among macrohabitat types or over time cannot be conducted due to different and non-comparable methods of gear types (i.e., fyke net versus electrofishing There is also evidence that juvenile Chinook Salmon and other fish species were misidentified or unidentified to species.

Modification 1: NMFS recommends spring sampling during May or early June at FDA sampling locations as described within the RSP and FDAIP (5.9(d)(1)). Spring sampling was not conducted as described in the RSP and the FDAIP to identify Middle and Lower River juvenile salmon rearing habitats.

Macro- and mesohabitats were not correctly classified, resulting in fish data that cannot be accurately assigned to a representative habitat classification type. A large number of juvenile salmon were speciated, and data presented within the Initial Study Report (ISR)(June, 2014) and to the Technical Working group supports the conclusion that juvenile Chinook, Coho, and Sockeye Salmon were misidentified. Different and incomparable fish sampling gear types were used at different locations and at different times that did not allow for comparisons to determine fish habitat associations. The distribution and temporal occurrence of juvenile salmon life stages is necessary to know when, where, and for which species and life stage habitat models developed through study 8.5 should be applied. Proposed operational scenarios would store spring flows within the reservoir, severely altering spring flows downstream. Understanding the spring fish distribution and habitat associations is necessary to evaluate project effects. Spring sampling will provide seasonal distribution of fish species by life stage and indicate overwintering locations. The spring sampling should be paired with the two summers and one fall sampling events.

Monthly sampling was not conducted at sampling sites as described in the proposed study plan and as summarized in the FERC study plan determination. AEA's RSP proposed year-round monthly sampling. The PSP page 7-13 states that electrofishing would occur monthly. The FDAIP (page 7) states that sampling will be conducted every other month during the months of May through October. The FERC study plan determination states, "Generally, sampling would occur monthly at all sites for fish distribution and relative abundance surveys during the ice-free season. At focus areas, sampling would occur monthly year-round and biweekly after break-up through the first of July to characterize the movements of juvenile salmonids during critical transition periods from spawning to rearing habitats." We recommended in March of 2013 that sampling within all sampling units occur once in early spring following breakup (May or early

June), twice during the summer (July – August) and once in the fall, mid-September to early October.

FERC supported the proposal for spring sampling, but stated that AEA was proposing to conduct biweekly ELH studies at all sampling locations. ELH sampling was not proposed for or conducted at all sampling locations; ELH sampling units were smaller; and ELH sampling methods were different than the FDA study. We do not believe that ELH sampling can replace spring FDA sampling.

The approved sampling plan for ELH described biweekly spring sampling at six 40 m sampling units within focus areas near known spawning locations. FDA spring sampling was to be conducted within all focus areas and non-focus areas in sampling units of 200 m to 500 m depending on location selected using the Generalized Random Tesselation Stratified (GRTS) method. ELH sampling was to be conducted using fyke nets to replicate 1980s studies.

FERC recommended two summer sampling events but did not adopt the spring or fall sampling schedule, or monthly sampling schedule proposed by AEA. The project currently has no spring FDA data for the Upper, Middle, or Lower River to identify whether juvenile or resident fish moved into or overwintered in tributaries or the mainstem.

Modification 2: NMFS recommends the study plan be modified to classify Middle River macrohabitats as Level 3 macrohabitats. Sampling units should be selected, sampled, and reported as described within the FERC-approved study plan. Macrohabitat classification using the approved habitat classes needs to be completed, along with the field verification prior to additional site selection or field sampling (see comments on Study 9.9). Macrohabitats should include only those approved in the FERC study plan determination: main channel, side channel, split channel, multiple split channel, tributary mouth, side slough, and upland slough.

Sampling locations in the Middle River did not include entire tributary mouths or the mouths of side sloughs and upland sloughs as defined within the FERC study plan determination. Macrohabitat sampling units were sub-sampled the 200 m or greater sampling units by flow type (level 4 mesohabitats).

The RSP and FDAIP and FERC study plan determination proposed to select sampling units based on macrohabitat (Level 3) classification (i.e., main channel, split main channel, side channel, etc.). However field sampling, data analyses, and reporting within the ISR were conducted at the mesohabitat (Level 4) classification. This is a deviation from the approved study plan and does not comply with generally accepted scientific practices. The results cannot be used to test for differences among macrohabitats and do not meet the study objective.

The approved study plan called for randomly or systematically selected sampling units based on macrohabitat classification for mainstem and off-channel macrohabitats. Mesohabitat (level 4) classification in focus areas had not been completed prior to the 2013 sampling season. In order for sampling to be conducted at the mesohabitat level, the distribution of mesohabitats structured within macrohabitats must be identified prior to site selection. Fish sampling stratified by the distribution of these mesohabitats to generate relative abundance estimates for other strata:

macrohabitats, focus areas, non-focus areas, or geomorphic reaches. In addition, without knowing the distribution of mesohabitats (level 4) within each macrohabitat (level 3) (e.g., percent pool, riffle, run backwater), and the sampling effort applied to each mesohabitat, it is not possible to know if samples were representative of the macrohabitat sampling unit. Therefore, the study objective cannot be met with FDA data as collected and reported in the ISR.

In the field, mesohabitat sampling units were classified and sampled based on flow type (e.g., riffle, run, glide). At Technical Work Group (TWG) meetings, preliminary fish counts were provided based on macrohabitat. The ISR presented data by mesohabitat (flow type). These inconsistencies render it difficult or impossible to determine the fish-habitat associations from these mesohabitats.

Modification 3: NMFS recommends that tributary mouths be sampled as macrohabitat units at the confluence of tributaries with the Susitna River main channel and side channels. AEA sampled tributary mouths based on visual estimates of clear water plumes only.

Tributary mouths should be selected and sampled as complete units. FERCs study determination recommended that clearwater plumes be classified at level 4 and specified that tributary mouth sampling units to include the tributary mouth and 200 m downstream. This approved method was not used. AEA sampled clearwater plumes independent of the whether they were tributary mouths, based only on presence of clear water plumes.

Entire tributary mouths should be sampled and not just the visible clearwater plume. Measures of turbidity are often used as an indication of water clarity. Differences in turbidity can also influence fish distribution. Visual estimates of water clarity are not a good substitute for differences in turbidity. Water is visibly clear at turbidities of 5 NTU or lower, while water appears turbid at values as low as 10 NTU. In addition, shallow, highly turbid waters where the streambed is visible often appear to be clear. However, there are large differences in fish habitat quality between 10 NTU and 200 NTU waters even though they both appear turbid. Classifying clear water plumes based on visual observed clarity, and sampling at this mesohabitat level, excluded sampling downstream of tributary mouths where water turbidity could be much lower than the mainstem and provide better habitat quality, increased food resources, and yet not be visibly different from the mainstem.

Tributary mouths provide unique habitats, and are biological hotspots as they represent mainstem locations of distinct water quality and increased production due to tributary sources of organic matter and macroinvertebrate drift. Therefore, we requested that FDA sampling occur within the tributary mouth and continue downstream for 200 m. FERC supported this recommendation in their April 1, 2013, Study Determination. We also recommended that invertebrate drift sampling (River Productivity 9.8) be conducted above and below tributary mouths to determine if these were locations of additional food resources. However, selecting sites as either tributary mouths or clearwater plumes resulted in site selection at the mesohabitat level and sampling was not conducted 200 m downstream from the tributary mouth. This change of sampling methodology prevents effective evaluation of these unique habitats.

AEAs selection of clearwater plumes as a unique sampling unit disassociated this mesohabitat from the associated tributary. In some cases only the clearwater plume was sampled and in other cases the tributary mouth delta was sampled and not the tributary mouth habitat downstream. Tributary mouths level 3 classification) are easily identifiable during all seasons independent of turbidity differences between tributaries and the mainstem. Turbidity water temperature, invertebrate drift and other water quality characteristics will be different in the mainstem downstream from a tributary mouth whether differences are visible or not. Tributary mouths should be sampled as complete and distinct macrohabitat units.

Modification 4: NMFS recommends a study modification to clarify that mainstem sampling unit selection should be consistent with the selection and sampling of other mainstem level 3 macrohabitats. NMFS recommends that main, split main, and multiple split main channels be lumped into one macrohabitat.

All three provide a turbid, fast-water, relatively deep environment. It is a safe assumption that temperature and DO are similar. Sub dividing them triples the number of sampling units needed. Once combined, they should follow the sampling procedures laid out in the RSP for main channel macrohabitat and, as requested, by study modification #6 and #7 in this document.

To date AEA has said these main channel habitats were 3 separate macrohabitats, but they did not sample the 10 replicates of each macrohabitat. With low to no replication the study cannot draw conclusions.

Modification 5: NMFS recommends the study be modified to clarify that classification of sloughs needs to be based on deviations in the mainstem bank contours. We do not support the classification of the downstream extent of sloughs based on water clarity as implemented by AEA.

Side sloughs and upland sloughs were not sampled from the beginning of the downstream mainstem confluence and extend a minimum of 200 m upstream as required by the study plan determination. Sloughs were reclassified as beginning with the presence of visibly clear water. The result of AEA's modification was to redefine sloughs and backwaters to make them separate rather than placing backwaters as a level 4 classification within macrohabitats as required by FERC in the study plan determination. The Initial Study Report for Study 9.6 states that "sloughs were differentiated from backwater habitat by clearwater." This change in classification eliminates the possibility of a level 4 backwater being contained within a level 3 slough (this was subsequently changed in the October 2015 line mapping in Study 9.9). This change in classification is based on water clarity and not on channel morphology as used for the other macrohabitat classes. This classification approach also results in all backwaters being equal, and not associated with a macrohabitat. It is more likely that fish use of a mainstem backwater will differ from fish use of a side slough backwater based on differences in water quality and other microhabitat characteristics that may not be identified through the 8.5 Instream Flow Study (IFS) habitat modeling. In addition, the backwater mouths of tributaries and side sloughs often have backwaters with low turbidity (e.g., Whiskers Creek and Slough 6A, respectively). By implementing the FERC approved study methodology, fish sampling would have been conducted within the backwater mixing zone of side and upland sloughs. The 200 m sampling units would likely extend from turbid to less turbid or clear water. The sampling scheme identified in the study plan determination would have provided data necessary to determine fish use the backwater mouths of off-channel habitats, which will be the most impacted by altered river stage height.

Modification 6: NMFS recommends a study modification to require macrohabitat unit sampling, as described within the FERC study plan determination. These are 200 m sampling units or 20 x channel width of side sloughs, upland sloughs and tributary mouths. For sloughs, sampling should begin at the downstream mainstem confluence to include the mixing zone of turbid and clear water, when present, and extend upstream into the slough. For tributary mouths, sampling should include the portion of the tributary influenced by the mainstem (zone of hydraulic influence) and 200 m downstream whether or not a clearwater plume is visible. Boat electrofishing and set gillnets in main channels and side channels should effectively sample fish in the entire 500 m sampling unit.

The FERC study determination clearly defined sampling unit lengths for the primary macrohabitats. FERC also defined the locations where sampling units should be selected in upland sloughs and side sloughs to capture the confluence of those habitat types with the mainstem and tributary mouths. This determination recognized that these are unique transitional habitats between main channel and off-channel habitats. AEA did not sample these areas nor sample entire sampling units as recommended by FERC, and therefore, did not implement the approved study plan. Decreasing the lengths of sampling units, results in underestimates of fish distribution and community diversity (AEA 2014).

Our recommendation on the RSP and to the TWG was that consistent fish sampling methods with comparable gear types be conducted such that differences in relative abundance by species and age class could be compared among habitat classification types. This is one of the most critical steps in determining the habitat associations of fish species necessary to meet the study objective. The generally accepted scientific practice is to apply consistent methods and effort among sampling units (i.e., mainstem macrohabitats). The application of consistent and comparable sampling gear types is necessary to apply the generally accepted scientific practice to test for statistical differences in fish abundance or community composition among habitat types or trends in fish metrics due to differences in physical or chemical characteristics (Appendix A).

The ISR describes fish collection methods that varied in sampling unit, methodology and effort. This resulted in fish data from electrofishing at one location or date, fyke net data at another date and/or location and time, and minnow trap data at a third date and/or location and time. Electrofishing effort varied from seconds at one location or one sampling date to 10 to 20 minutes at another. Units of relative abundance or community composition were different and not comparable among sites (i.e., catch/time/unit, catch/trap/unit, or catch/net/unit). Consistent sampling methods must be used to meet study objectives.

Modification 7: NMFS recommends modifying the study plan to sample using different gear types in the following sequential order:

- FDA sampling should include a minimum of 20 baited minnow traps fished for 20 to 24 hours are used for every 200 m of sampling unit length to document the seasonal distribution and relative abundance of juvenile Chinook and Coho Salmon.
- Following minnow trapping, backpack electrofishing should be used to obtain abundance estimates of salmon fry and resident fish species that are not effectively captured in minnow traps (Sockeye, Chum and Pink Salmon).
- Fyke nets, hoop traps, and beach seines can be used to augment minnow trapping and backpack electrofishing, for fish distribution, but should not be used to derive estimates of relative abundance.

Our RSP comments recommended that a sub-sample of nearshore habitat of main channel and side channels be sampled for juvenile species that may escape boat electrofishing and drift gill nets due to shallow depths and nearshore cover. In the ISR, AEA proposed sampling 200 m lengths of main channel and side channel habitats if boat electrofishing or drift gill netting is not used. We opposed this proposed modification because it will result in different sampling methods being applied to different sampling units. Use of differing sampling methods does not allow for accurate testing of differences in fish abundance among main channel and side channel sampling units or with off-channel habitats absent an accurate conversion factor. Sampling smaller main channel and side channel habitats using minnow traps and backpack electrofishing will likely underestimate the distribution and abundance of Grayling, Dolly Varden, whitefish (spp.), and Burbot whose probability of capture is lower when using these methods in the nearshore zone. Whereas, mainstem sampling using only boat electrofishing and drift nets will underestimate the distribution and abundance of juvenile salmon. Consistently sampling 500 m mainstem habitats by boat electrofishing and drift gill netting and a 200 m sampling nearshore unit with backpacking electrofishing and minnow trapping will apply methods suitable for all target fish species at all sampling locations and provide comparable measures of fish abundance within and among macrohabitat types.

Baited minnow traps are an effective method for capturing juvenile Chinook and Coho Salmon (Appendix A). Multiple traps are necessary to obtain a consistent measure of relative abundance. When only 2 or 3 traps are used, all available habitats (i.e., depth, velocity, substrate, cover) are not sampled and result in a wide variability in catch data. The use of 2, 3, or even 10 traps is insufficient sampling effort for a 200 or 400 m sampling unit and is similar to considering 15 seconds of electrofishing adequate time for a similar sized area. Minnow trapping also is not disruptive and should not affect the catchability of other sampling methods. Minnow trapping is not subject to the same restrictions by the ADFG collection permits which have restricted the use of electrofishing in the presence of adult salmon. Therefore this method can be consistently applied within all sampling units on all sampling dates, including winter.

Following minnow trapping (after traps are pulled), the sampling unit should be sampled using backpack electrofishing. Backpack electrofishing will capture those species not readily captured in minnow traps including juvenile Chum and Sockeye Salmon, resident Rainbow Trout, Arctic Grayling, Dolly Varden, and whitefish. Consistent sampling effort should be applied for all sampling units so that relative abundance is not underestimated or overestimated due to excessive or insufficient effort, respectively. Fyke nets, hoop traps, drift nets and beach seines could be used for presence or absence (distribution) but should not be used as measures of relative abundance as these methods cannot be effectively fished in all sampling units. The application of these methods in this order will provide consistent and comparable measures of relative abundance among sites that can be used for statistical analyses used in generally accepted scientific practice.

Modification 8: NMFS recommends the study be modified to include in reporting: of sampling locations, sample unit length and area, date, methods, effort by gear type (i.e., electrofishing time, number of seine hauls, number of minnow traps and hours fished, snorkel time, number of fyke nets and hours fished) by macrohabitat classification.

FERC regulations 5.9(b)(6) states that proposed studies need to be consistent with the generally accepted practice in the scientific community. This includes data collection, analyses, and reporting. The generally accepted scientific practice is to clearly describe the study sampling design. Objectives should be measurable and methods should be described with enough detail to be repeatable.

Modification 9: NMFS recommends a study modification for tissue samples (belly swab with q-tips) for genetic analyses be collected from 1 in 10 juvenile salmon to confirm species identification, pre-season field crew training in fish identification regarding juvenile salmon identification..

Based on our review, juvenile salmon were not identified correctly by AEA field technicians. This conclusion is based on data presented in the ISR, ISR meetings, and through genetic analyses conducted by the ADFG. The habitat associations, age class information, and size frequency distribution of juvenile Chinook Salmon reported in the ISR are inconsistent with other regional studies (Appendix B). Juvenile Pink Salmon were generally absent from 2013 samples even though there were large numbers of returning adults in 2012 (e.g., Deshka River return of 79,000). At the September 23, 2013 TWG meeting AEA reported juvenile Sockeye Salmon as the primary species captured in the Montana Creek screw trap (261 sockeye through July 2013) (Figure 2). However, the ISR does not report any Sockeye Salmon in Montana Creek screw traps (ISR 9.6 Table 5.21 and Figure 5.2-4). Data presented at the TWG meetings were preliminary; however these inconsistencies along with misidentification of Chinook and Coho Salmon, and the large number of unidentified whitefish in the Upper River raise concerns regarding the accuracy of species identification.

Figure 1. Slide from AEA TWG presentation reporting sockeye salmon juveniles as the dominant species captured in Montana Creek screw traps.

In response to comments by NMFS, the U.S. Fish and Wildlife Service (USFWS) and ADFG prior to and at the ISR meetings regarding inaccurate species identification, AEA developed a draft Chinook and Coho salmon identification protocol. Published protocol for identifying juvenile salmon and other fish species was submitted to FERC in Section 5.1.4 of the Susitna River FDAIP as a supplement to the RSPs (R2 Resource Consultants 2013). The new draft protocol does not propose any substantial changes to the procedures outlined in the FDAIP.

NMFS recommends that field crews are provided the appropriate species identification training prior to working in the field.

Modification 10: NMFS recommends Lower River sampling units be selected based on macrohabitat classification for determining fish habitat associations. NMFS also recommends the study be modified to conduct macrohabitat sampling based on macrohabitat classification in a minimum of 10 tributary mouths, side sloughs, upland sloughs, side channels, and main channel habitats.

Transect-based sampling was used in the Lower River and resulted in samples being collected in far proximity from mainstem or underrepresented off-channel habitats important for juvenile salmon. Sampling in side sloughs, tributary mouths, and upland sloughs should occur at the confluence with side channels or main channel as described in the FERC study plan determination. Lower River sampling units must adequately replicate available habitats to document the distribution of fish within the Susitna River and test for differences in relative abundance among river segments, geomorphic reaches, and macrohabitats. Our RSP comments recommended selecting sampling units based on macrohabitat classification and not using the transect approach.

The FERC study plan in the Lower River for sampling unit selection in off-channel habitats was not implemented, limiting the utility of this information. Lower River sampling sites are displayed on maps in the ISR for Study 9.6. These maps show that sampling locations were not selected per the study plan. These habitats were sampled at transect locations instead in side sloughs and upland sloughs from their confluence with the mainstem and upstream 200 meters.

The sampling location and unit length were recommended to minimize within-macrohabitat differences in microhabitat variables (i.e., low dissolved oxygen at the shallow upwelling areas at the head of sloughs vs. more oxygen-saturated confluence areas), to exclude potential pseudo-replication sites (i.e., sampling different areas of the same slough as a replicate of the macrohabitat), and to standardize sampling effort among locations and sampling seasons.

Side slough, upland slough, tributary mouths, and side channel habitats were underrepresented in the sampling effort, with effort instead being allocated to additional habitat types, including tributaries, slough mouths, and "additional open water." There was no clear objective for how information from sampling these habitat types will be used. This must be determined in advance rather than gathering data not in accordance with the study plan, and then trying to determine after-the-fact how to interpret it. Four side channels, two upland sloughs, and three side sloughs were sampled to represent over 100 river miles (AEA Table 4.1-4), this is not adequate for a habitat based sampling plan and supports the need for NMFS request for a new study of Model Integration.

Lower River site selection and sampling was not conducted as proposed. New information from the instream flow routing study (8.5), adult escapement study (9.7), and FDA study (9.6) indicate that the Lower River is likely important for the summer rearing and overwintering of juvenile salmon, and project effects are now known to extend to Lower River reaches. FDA sampling was not effective at identifying juvenile salmon and resident fish rearing and overwintering locations. For example only 179 juvenile Chinook Salmon, 413 juvenile Coho Salmon, and 751 juvenile Sockeye Salmon were captured over all sampling periods and all sampling locations in the Lower River (AEA Table 5.1-3; excluding tributary screw traps and tributary samples but including ELH and productivity sampling). Study results are not presented by macrohabitat; however, the low abundance of juvenile salmon is likely due to the under representation of off-channel side sloughs, upland sloughs, and tributary mouths and location of sampling units within these macrohabitats.

Flow modifications based on proposed operational scenarios will result in project effects to the Lower River. Adult escapement studies have documented Sockeye, Chum and Coho Salmon spawning in mainstem and off-channel habitats of the Lower River. Current and historic studies have demonstrated the movement of Chinook and Coho Salmon from spawning tributaries to the mainstem for rearing and overwintering. The Lower River tributaries provide some of the more important Chinook and Coho Salmon spawning habitat. Therefore, any Lower River project effects could influence not only salmon that spawn in the mainstem, but a portion of the juveniles from tributary spawning that migrate to the Lower River mainstem, including juvenile salmon from the Middle Susitna, Talkeetna, Chulitna, and Yentna Rivers. Project effects are not likely to be the same for all macrohabitat types as changes in water surface elevation will affect off-channel habitat more than main channel habitats. It is necessary to understand the distribution and habitat associations of juvenile salmon and resident fish to determine project effects to rearing salmon due to flow alterations to macrohabitats directly or to identify locations where instream flow studies and hydraulic modeling can be conducted.

Modification 11: NMFS recommends a study modification to address the relative importance of beaver ponds and complexes for juvenile salmon summer rearing and overwintering. Fish sampling should be conducted within 200 m sampling units within beaver ponds and in comparable macrohabitats without beaver ponds using 20 baited minnow traps set for at least 20 hours, spaced about 10 m apart during summer, at a minimum of 10 Middle River and 10 Lower River locations to test for differences in the relative abundance and size distribution of juvenile salmon in these habitats. This information will be used to evaluate the relative effects of project operations on the development and establishment of beaver ponds, and project operations that may affect fish access to beaver ponds and pond complexes.

The importance of beaver ponds for juvenile salmon rearing and overwintering (Malison et al 2014; Collen and Gibson 2011) require a study modification or study clarification to ensure that adequate sampling occurs within these habitats. AEAs RSP (RSP 9.4.6.1 and Figure 9.6.3) and the FERC study plan determination identified beaver ponds or beaver pond complexes as one of the strata for Middle and Lower River sampling. Beaver ponds or beaver pond complexes were sampled during the summer in the Middle River; however, no beaver ponds were sampled during the summer in the Lower River. During the winter many of the Middle River off-channel habitats sampled by AEA were located in beaver ponds (FA 104, FA 128, FA 138 see Winter Study comments, Appendix C). Middle River summer sampling also did not stratify level four beaver ponds, based on the macrohabitat in which they occurred (side slough, upland slough, and tributary) but selected sites within these mesohabitats when they occurred. We are also concerned that if AEA is required to sample the mouths of side sloughs and upland sloughs, beaver pond complexes will not be sampled. This study modification does not require any additional effort; rather, it ensures that during the second and subsequent years of study, sampling occurs within sampling locations with and without beaver influence in the Middle and Lower River during summer and winter.

RSP section 9.4.6.1 and Figure 9.6-3 both identify beaver complexes as one of the off-channel habitats to be sampled. The FERC study plan determination also identified beaver ponds as one of the Middle and Lower River sampling strata; however, beaver ponds in the Lower River were not sampled. Therefore, the FDA study was not conducted as provided for in the approved study plan.

We recommend ten randomly select Lower River beaver ponds for summer and winter FDA sampling. This study clarification is necessary to determine the juvenile salmon use of beaver pond habitats for summer rearing and overwintering. These habitats may be of special importance as the Lower River likely provides rearing and overwintering habitat for juveniles migrating from tributaries used by spawning Coho and Chinook Salmon. We recommend ten Middle River beaver ponds complexes be randomly selected for summer and winter FDA sampling. This modification or study clarification is necessary to ensure that these habitats and comparable habitats without beaver dam influence are sampled during summer and winter FDA studies.

Modification 12: NMFS recommends a study modification to document the Middle and Lower River fish distribution, habitat association and abundance during the winter months (Appendix C). Pilot studies conducted in 2013 demonstrated that winter sampling is feasible. However, monthly sampling within focus areas was not conducted as described in the study plan. Winter FDA sampling conducted in 2014 was limited in scale and was only conducted within a few focus areas with little replication of Susitna River macrohabitats. “Winter” sampling must occur from December after stable ice has formed and be completed by March before juvenile fish migration starts (April sampling is not winter sampling as fish have already begun to respond to changes in daylight and other seasonal conditions).

Winter sampling should occur at all Focus Area GRTS sampling locations selected for spring, summer (2 sampling events) and fall. Sampling units should include tributary mouths, and the downstream ends of all side sloughs and upland sloughs. Sampling should be conducted monthly at all sampling locations during November, January, February, and March using baited minnow traps at 20 locations. This sampling scheme includes under-the-ice sampling. Baited minnow traps are efficient for the capture of juvenile Chinook and Coho Salmon and can be used at open and under-the-ice sampling locations. Using the same methods at all sampling locations will allow for comparisons of relative abundance among sampling units and across time. Application of these methods will also provide data that can be compared to historic ADFG and current studies (Davis et al. 2013, 2015). Sampling locations within each sampling unit should be selected where open water of sufficient depth under-the-ice exists. Water depth and ice depth should be recorded at 20 locations within each sampling unit on each sampling date, even if sampling is not conducted due to insufficient water depth. Measures of water velocity, substrate size, woody debris, water temperature, dissolved oxygen and specific conductivity should be measured at all locations where fish traps are deployed. Backpack electrofishing, underwater video and fyke nets should be used to augment minnow trap estimates of fish distribution, where possible.

The approved study plan stated that sampling would occur monthly in all Middle River Focus Areas. The FERC study plan determination stated that sampling would occur monthly in all Focus Areas and “winter sampling efforts would utilize the same sampling locations but would be less frequent, approximately monthly instead of bi-weekly and for winter would be dependent on safe access and sampling methods (due to ice cover).” A pilot study was conducted at a subset of locations in 2013 and 2014 demonstrating that winter sampling is feasible. However, sampling has not been conducted monthly in all focus areas as described within the approved study plan. Therefore per 5.15(d)(1), the study was not conducted as provided in the approved study plan.

The need for winter fish distribution and abundance data and the nexus to project effects has been well established in previously proposed and revised study plans, study plan comments, and during TWG meetings. We proposed alternate methods in our RSP comments to accommodate access to sampling locations. FERCs study plan determination did not support our recommendations, stating, “AEAs phased approach is reasonable in the circumstances of this case," and "There would be additional opportunities throughout ILP pre-filing study implementation to evaluate the effectiveness of winter sampling methods and, if found to be effective, apply additional winter sampling efforts throughout the study area." However, since AEA did not submit ISRs following the first year of study, there was no mechanism for recommending study modifications prior to additional data collection in 2014.

Modification 13: NMFS recommends that the study plan be modified to include a description of how the various data will be turned into quantitative estimates so that rigorous comparisons can be made across species, river habitat types and sampling date. This modification would allow for direct comparison among the sampling design, estimates and statistical. This includes statistical tests to determine if differences in mean relative abundance measures are significantly different among habitat classifications at all classification levels 1 through 3, consistent with standard scientific practice. The approved study plan does not contain any section to describe the statistical analysis that will be applied to field data to address study objectives. This is not the accepted scientific practice, and results from the first year of study raise questions as to whether this can be accomplished (Appendix A). For example, the available reports provide a comparison of differences among sites based on mean values or total counts without consideration for differences in sampling method or effort. This is not standard scientific practice.

Modification 14: NMFS recommends a study modification to require juvenile salmon be identified to species. Fish should be identified to species. Individual species data should not be pooled with data from other species. In extreme circumstances of large sample size > ~500 of Sockeye and Chum are captured in a single fyke net or in an hour of screw trap operation, a minimum of 100 individuals or 25% of the total catch should be subsampled. Chinook Salmon are limited in their distribution and habitat requirements relative to Coho Salmon, and determining the distribution and habitat requirements of juvenile salmon species needed to describe the current environment and for evaluating potential project effects.

The juvenile salmon species error reported by AEA based on genetic analyses is an underestimate (SIR). Genetic samples were not collected randomly from all juvenile Chinook and Coho Salmon and likely are biased based on the confidence of field personnel. AEA reports that 28% of the juvenile salmon identified as Chinook were Coho Salmon in 2013 for all studies, locations, and sampling dates). When we evaluated the size distribution of age-0 Chinook Salmon from AEA Middle River samples (Excel tables for 2013 condition index), error for Chinook Salmon was estimated at over 50%. AEA's SIR shows the size distribution of Susitna River Chinook Salmon that were identified genetically (Table B-4). This is consistent with the size distribution of Chinook Salmon captured by ARRI (Figure 3) and by ADFG in the 1980s (Appendix B), with 99% of age-0 Chinook < 100mm in fork length. However, well over 50% of the fish reported by AEA as Chinook Salmon collected in the Middle River in 2013 are over 100 mm in fork length and are therefore, more likely to be age-2 Coho Salmon (Figure 3).

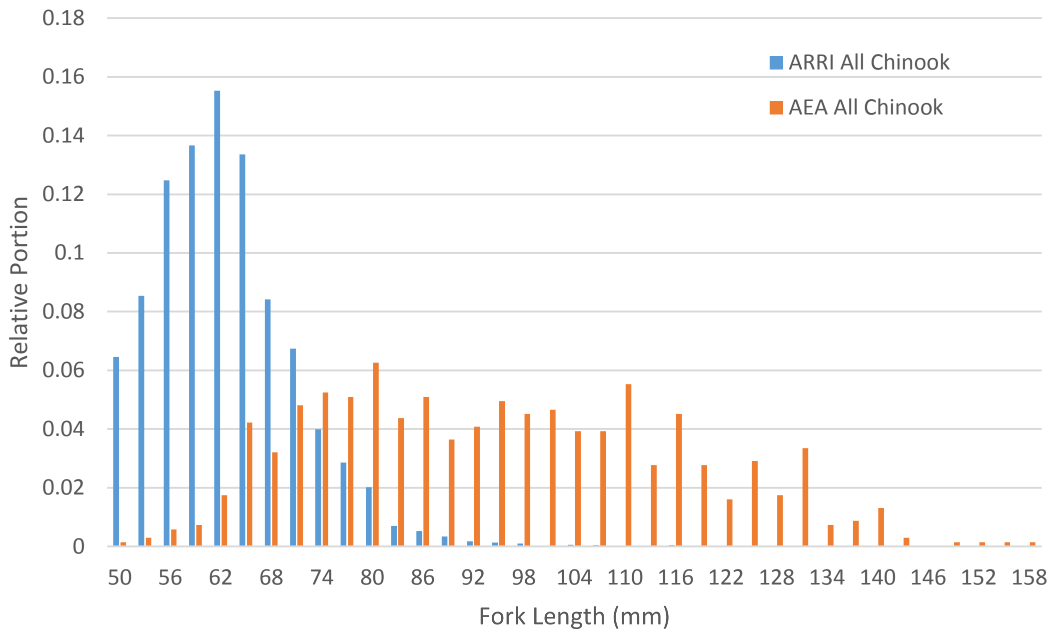

Figure 2. Size frequency of Chinook Salmon reported by AEA in 2013 condition factor table (n = 687) compared to size frequency distribution of Mat-Su Basin Chinook Salmon captured by ARRI (n = >7,000)(see Appendix B).

Studies have shown that Coho Salmon are ubiquitous in their distribution and are found under a broad range of habitat characteristics whereas Chinook Salmon are restricted in their distribution and tend to have a narrower range of habitat requirements. Winter studies and studies conducted throughout the Mat-Su Basin indicate that Chinook Salmon are present only in a subset of the sites where Coho Salmon are found and relative abundance of Chinook is often lower than Coho Salmon (Davis et al. 2014, 2015a, 2015b, Miller et al. 2011, Davis et al. 2015c). AEA's SIR shows large differences in the water velocities where Chinook and Coho Salmon fry and juveniles were observed, with Coho Salmon in much slower and deeper waters. Murphy et al, (1989) found that Coho Salmon in the glacial Taku River occupied habitats with significantly slower currents than Chinook Salmon and that Chinook were "virtually absent (mean <1 fish/100m^2) from beaver ponds and upland sloughs." Chinook Salmon are reportedly more temperature and oxygen sensitive and are most often found in fast-flowing, cold water habitats (Murphy et al. 1989; Quinn, 2005; Richter and Kolmes, 2005).

Chinook and Coho Salmon distribution also varies over time. Chinook Salmon have a 5-7 year life cycle and most spawning occurs in tributaries. Their distribution in mainstem habitats will be limited in spring and early summer. Coho Salmon are likely to be broadly distributed during this same time period. Chinook Salmon abundance is likely to be higher near spawning tributaries as juveniles migrate from natal tributaries (Indian River and Portage Creek) to the mainstem Susitna River.

Objective 2: *Seasonal movements of juvenile salmonids and selected fish species (Modifications 15-22)*

Modification 15: NMFS recommends a study modification to require a mark-recapture study to measure the efficiency of the rotary screw traps. If conducted carefully and with adequate numbers of recaptures, results of this study could provide an estimate of the abundance of fish migrating past the rotary trap and trap efficiency, and address questions regarding the accuracy of results documenting juvenile salmon movement patterns from migrant traps (rotary screw traps) at the mouth of the Indian River and Montana Creek. Screw trap efficiency was not examined and the portion of juvenile salmon moving from tributaries to the mainstem for rearing and overwintering cannot be estimated. The PIT tag studies were largely ineffective and did not provide information on the proportion of juvenile Chinook or Coho Salmon from tributary spawning locations that moved to the mainstem for rearing and overwintering. Movement patterns of most resident fish were not identified due to the low number of radio tagged fish and the failure to track these fish as described within the approved study plan.

Modification 16: NMFS recommends a study modification to require downstream migrant traps (rotary screw traps) be deployed immediately following breakup and operated throughout the open water season to obtain two full years of migration data at four locations including the Indian River, mainstem near Curry, mainstem near Talkeetna Station and Montana Creek. Trap efficiency and abundance estimates should be conducted as described within the approved sampling plan. NMFS is recommending that the out-migrant screw traps in the Indian River and Montana Creek be operated 7 days a week to determine the proportion of tagged juvenile salmon migrating from these tributaries.

The downstream migrant screw traps were not installed immediately following breakup and trap efficiency was not tested. The late installation was due to anomalous environmental conditions, with breakup occurring later than usual. The proposed operational scenarios include water storage during spring. It is important to determine when smolts from five pacific salmon species migrate from the Susitna River drainage and when juvenile salmon from spawning tributaries migrate to the Susitna River for summer rearing and overwintering.

Problems were encountered with debris loads and flood events, resulting in sampling periods where traps were not operational. The Indian River trap was not functional from August 22 to August 26 and September 2 to September 15, the Montana Creek trap was not functional from August 24 to August 28 and September 4 to September 13, and the Susitna River trap was not functional from August 24 to August 28. The Curry Station trap was removed in early September to replace the damaged Indian River trap. Due to the relatively small number of fish caught at the Curry Station and the truncated sampling period, migratory timing data are incomplete. Juvenile salmon were caught immediately on installation of all four traps, indicating that downstream migration of juveniles was already underway in mid-June.

Migratory timing statistics such as those proposed by Mundy (1982) and used in many escapement studies (i.e., Boyce and Andel 2012) could provide another alternative to describing and comparing downstream migration. Estimates of mean day of migration and variance in day of migration are an alternative way to summarize these observations and provide statistics that can be compared across species and traps.

Modification 17: NMFS recommends modifying the study to require rotary screw traps be used to augment PIT tag recovery. The PIT tag antenna was not effective at recording tagged fish in Montana Creek and the Indian River due to the size of these stream systems. Therefore, the proportion of PIT tagged juvenile salmon exiting these tributaries, timing and age classes could not be determined. Screw traps will need to be operated seven days a week to efficiently capture PIT tagged fish.

Modification 18: NMFS recommends a study modification to require anadromous salmon captured in migrant traps >45 mm fork length be measured to validate species identification and age class (i.e., age-0, or age 1+). Fish data should be reported by age class based on size frequency distributions or by fork length.

Studies conducted were unable to provide descriptions of juvenile salmon age classes, growth, or condition among macrohabitat type. The RSP, FDAIP, and FERC study plan all differed in stated sample size for species age, length data. Sample sizes by species within each macrohabitat were insufficient to determine differences in age classes, lengths, condition, or growth by macrohabitat type. Inaccurate species identification invalidated many results. Few PIT tagged fish were recovered. The study contained no mechanism to determine if fish tagged or recovered were representative of the population.

The age class designations used by AEA (fry, parr, juvenile, and smolt) are subjective and do not contribute toward meeting study objectives. There is no clear distinction within the study methods to differentiate between salmon fry and parr, or parr and juveniles or juveniles and smolt. Chum and Pink fry are also smolt, as they migrate immediately upon emergence. Further, results in the Study 9.6 Figures are contradictory and suggest misidentification of fish.

Providing results based on fish length would require no additional effort. SIR Table 4.7-2 reports that fish lengths and weights were obtained for a large number of juvenile salmon species. In reviewing AEAs Excel table of fish lengths from 2014 ELH sampling multiple entries for fish life stage are contradicted by fish fork lengths (i.e., Parr assigned to fish with FL < 50 mm). Age and length data of fish captured in outmigrant screw traps were not documented. As noted in the review of study methods it is not clear how many fish were to be measured for fork length or weighed. ISR 9.6 reports the timing of juvenile salmon movement by life history stage; however, there is no supporting documentation of how life history stages were determined.

Modification 20: NMFS recommends a study modification of the PIT tagging study to be conducted as required in the study plan determination, including evaluation of detection efficiency, and be modified such that the data can determine the movement patterns of juvenile salmon from spawning tributaries to the mainstem and off-channel habitats.

The primary objective of the PIT tagging study and fish sampling with screw traps is to determine when juvenile salmon of different age classes and tagged resident fish migrate from spawning tributaries to the mainstem Susitna River. The PIT tagging study was not conducted as approved in the study plan determination. To do this antennas must be relocated from Slough 8A, Montana Creek and Indian River, and installing these antennas at the Whiskers Creek site to develop antenna arrays to document direction of movement. The screw traps in Montana Creek and Indian River should operate seven days a week to capture migrating tagged and untagged fish. Detection efficiency should be calculated for the antenna arrays. Increased sampling and tagging efforts of juvenile salmon should be conducted within Whiskers Creek, Indian River, and Montana Creek to determine the proportion of juvenile salmon from tributary spawning locations that migrate to the mainstem Susitna River for rearing and overwintering. This modification will require the trapping and tagging 500 Chinook, 500 Coho, and 500 Sockeye Salmon that are >50 and < 80 mm fork length in each tributary during both summer and single fall sampling dates.

The PIT tag study was not conducted as described in the approved sampling plan: antennae arrays were not installed such that upstream and downstream migration could be detected. Detection efficiency was not determined so the proportion of tagged fish moving cannot be estimated. Tagged fish that were captured in screw traps need to be included when reporting on movement patterns as required by the study plan determination.

The PIT tag antennas in Indian River and Montana Creek could not cover the entire channel and were therefore installed in side channels. Due to the incomplete array coverage, many tagged fish were not recaptured with a signal reading. The resulting was that there is limited data that can be used to address the study objective. In order for the pit tagging study to be useful tagged fish need to be detected and detection efficiency needs to be determined.

Whiskers Creek is the only study location where PIT tag antennas could cross the channel. However, this antenna was not operational for many days and detection efficiency was unknown. In addition, only a single antenna was used. Direction of movement could not be determined.

For the Montana Creek and Indian River systems, tagged fish will need to be recaptured. NMFS recommends using screw traps to recover tagged fish. This approach will require operating the screw traps seven days a week to improve recovery of tagged fish. Detection efficiency of the screw trap must be determined using tagged fish as provided for in the approved plan.

The usefulness of the PIT tagging results are limited by the inability to estimate the percent of PIT tags detected at an antenna site (detection efficiency), the inability to detect the direction the fish was traveling when it passed detection arrays and the low percentage of PIT tags that were detected (12%) or recovered (3%). The low percentage of PIT tags detected possibly indicates a low efficiency of the antennas or that tagged fish did not migrate in the direction of the antenna. The recorded tags detected also included multiple detections of the same tag on different days and in the same area as released, indicating that some tagged fish tended to stay in the same area. It is difficult to interpret the data without direction of movement.

PIT tagging should help identify the proportion of the juvenile Chinook Salmon from adults spawning in the Indian River, and rearing and overwintering in the tributary verses migrating to the Susitna River mainstem. Juvenile salmon rearing and overwintering in tributaries would be less subject to project effects than those juveniles rearing and overwintering in the mainstem Susitna River. The PIT tag study was not conducted as described in the approved study plan.

Antennae arrays were not installed and detection efficiency was not estimated. PIT tag antennas in the Indian River and Montana Creek did not cover the entire channel.

Modification 20: NMFS recommends modifying the study plan to require untagged juvenile salmon captured in the screw traps are tagged be released downstream or used only to test trap trap efficiency. Otherwise results are biased by the movement patterns of fish already migrating.

Modification 21: NMFS recommends expanding the geographic extent of fish sampling and PIT tagging to include Whiskers Creek, Montana Creek, and Indian River during the two summer and single fall FDA sampling events. A minimum of 500 Chinook, 500 Coho, and 500 sockeye should be tagged in each stream during each sampling event at each location. Sampling locations and methods within each tributary should be completed as provided in our RSP comments.

Our RSP comments (summarized in the FERC study determination) were, "NMFS and FWS state that five 400-meter long fish sampling locations should be located in Indian River and stratified longitudinally from the PIT tag array site to the farthest upstream Alaska Railroad crossing. The agencies state that five 400-meter fish sampling locations should be located in Montana Creek from the Parks Highway extending upstream to Yoder Road. The agencies request that five 200-meter long fish sampling locations should be established in Whiskers Creek at 1,000 meter intervals extending upstream from the Susitna River confluence. The agencies recommend that fish sampling be conducted in these locations using a combination of electrofishing and minnow trapping as described previously to capture juvenile coho and Chinook Salmon for PIT tagging." The purpose of this recommendation was to ensure that tags were applied to those fish under investigation. In order to determine the proportion of fish from spawning tributaries that migrate to the mainstem, it is necessary to tag these populations. Tagging fish from mainstem screw traps and FDA sampling locations did not, and will not, meet this objective.

Modification 22: NMFS recommends a study modification for additional radio tagging. The radio tagging study should be modified to include (a) distribution of tagged fish equally among geomorphic reaches or proportional to the relative abundance of target fish species; (b) use aerial over flights to contrast with boat, foot, or snow machine tracking as described in the RSP; (c) additional fish should be captured during winter as proposed; and (d) status of recaptured fish ascertained.

The radio tag study objectives were not met based on data presented in the ISR and subsequent 2013/2014 Winter Fish Study Technical Memorandum. Specifically, resident fish spawning, foraging, and overwintering locations and characteristics have not been identified. AEA proposed to place at least 30 radio tags within target fish species, to provide two years of data to represent the migration patterns of fish populations within the Middle and Lower River. Target species for this study component are: Arctic grayling, Burbot, Dolly Varden, Humpback Whitefish, Lake Trout, Longnose Sucker, Northern Pike, Rainbow Trout and Round Whitefish. Most fish were radio-tagged in Geomorphic Reach MR-6, followed by MR-8. Only Arctic Grayling were radio-tagged in Geomorphic Reaches MR-1 and MR-2, the areas directly below the proposed dam site and above Devil's Canyon. Although Round Whitefish were found in all geomorphic reaches, only fish from MR 6 (20 fish) and MR 8 (1 fish) were radio-tagged. A more uniform distribution of radio-tags released throughout the drainage would provide a more detailed assessment of migration from and into different river areas. Radio-tagged fish were tracked from July through early October using weekly aerial surveys and monthly aerial surveys after early October.

Dolly Varden. 2013 tagging goals were not met. A large portion of the tagged fish was tagged in the Talkeetna drainage at the mouth of Clear Creek (Chunilna). Approximately 121 Dolly Varden were captured in the Middle River; however, only nine fish were radio-tagged.

Tagging goals were not met during 2013 for Burbot. The winter spawning locations and habitat characteristics of sites used by Burbot and whitefish were not identified. Fish were not tracked to spawning locations and the location of tags was often reported at a scale of ± 10 or more miles. Over 400 Burbot were captured in the Middle River; however, only seven Burbot were tagged, and only three of those were in the Middle River.

According to the Radio Tagging file, 29 Arctic Grayling were tagged in the Middle River; however, most of these fish were in tributaries above the canyon, with only 11 Arctic Grayling tagged in the Middle River at Curry. Over 2,000 Arctic Grayling were reported captured in Middle River FDA sampling and DMT. In August 2013, 20 tagged Arctic Grayling were reported still alive.

AEA tagged 28 Longnose Suckers. None of the tagged fish were in the Lower River, and three of the tagged fish were from the Talkeetna River drainage.

Tagging goals were not met for Humpback Whitefish during 2013. One hundred and nineteen fish were captured in the Middle River; only seven were fish tagged.

Tagging goals for Round Whitefish were met during 2013. Twenty fish were tagged within the Middle Susitna River, primarily from Curry and the adjacent 4th of July Creek.

All Northern Pike captured were radio-tagged; all tagged Northern Pike were from Kroto Slough. The tagging effort did not meet tagging goals.

Winter biotelemetry observations were mostly limited to monthly aerial surveys for radio tags. As only the fixed stations at Whiskers Creek, Indian River, Devils Island and Kosina Creek were operated October-June (none in the Lower River), and the fixed receivers are only operational above -4°F, there was likely little data collected between aerial surveys. The ISR also stated that up to 23 of the 157 tags released in the Middle and Lower River (15%) could stop transmitting by the end of 2013 (based on battery life), and only 54 tags were still transmitting in January of 2014 (34%). This reduces the ability of radio tag data to describe fish movements to spawning/ rearing locations during the winter or spring before later tagging efforts and supports the need for tagging efforts of target fish to begin immediately before estimated spawning seasons.

Objective 3: *Describe early life history, timing, and movements of anadromous salmonids. (Modifications 23-25)*

Modification 23: NMFS recommends modifying the study plan to require ELH studies be conducted on all sampling dates at all Focus Areas as described in the RSP and add minnow traps and fyke nets with hoop traps in all sampling locations on all sampling dates. All traps, nets, and hoop traps should contain mesh sizes of 1/8 inch or less.

The implementation of the ELH studies in 2013 did not achieve the study objectives. Determining emergence timing and habitats selected by emergent salmon was not accomplished. Few emergent salmon were captured, and data were not obtained on habitats selected by emergent and migrating sockeye salmon or other juvenile salmon species. The study did not identify the length of time fish < 50 mm were present or most abundant within the Middle River focus areas. Review of the ELH data (ISR9_6_FDAML_FishObservations-Excel) and results presented in the ISR indicate that selection of sampling locations, inconsistent sampling methods, and misidentification of juvenile salmon prevented the study from meeting the stated objectives. The number of focus areas sampled and frequency of sampling was less than proposed within the FERC approved study plan. Fish collection methods and sampling gear did not follow the approved plan and those selected in 2013 were not appropriate or effective for sampling newly emergent salmon fry. The differences in emergent fry abundance among sampling locations or over time could not be compared because different sampling methods were used in different sampling units and on different dates.

The FERC approved study plan described bi-weekly sampling from ice out through July. During normal years, breakup generally occurs the first of May, which would result in 3 or 4 sampling events. According to the approved study plan, sampling would occur within six, 40 m sampling units within Middle River focus areas that support salmon spawning. Fyke nets were to be used at all sampling locations to replicate methods used previously for the capture of emergent salmon. The RSP section 9.6.4.3.3 states that fyke nets will be used to capture emerging fry on a bi-weekly basis beginning in mid-April in each of the monitored side channels, following methods used in the 1980s. However, in 2013, fyke nets were only used during some sampling events and within some sampling units and were replaced at other sampling units with methods and gear types that are not effective for newly emergent juvenile salmon.

In 2013, ELH sampling was conducted in late April at three Focus Areas (FA104, FA128, and FA138) and twice in June at six Focus Areas. In April, sampling was conducted only at a subset of the proposed six sampling units within each Focus Area. Different sampling methods were applied at the same sampling site on different dates and different sampling units within the same focus area. Many of the methods used are ineffective at capturing emergent salmon and in particular, emergent Sockeye and Chum Salmon. In April, electrofishing was used at all sampling locations instead of fyke nets; however, during the two first June sampling electrofishing was used in some sampling units and minnow traps in others. At FA-128 (Slough 8A), a total of 42 pacific salmon fry and juveniles were captured during ELH sampling, with only 19 of these fish < 50 mm (fry). All these fry were captured at sites 128-01 and 02 during late April by electrofishing. During the first June event, these two sites were sampled with a fyke net and during the second June event a fyke net was used at 128-01 and a seine at 128-02. No additional fry were captured at these sampling sites. This could be due to differences in sampling methods or fry absence in June. The mesh size for fyke nets and seines used was 0.25 inches which salmon fry < 45 mm can pass through. Therefore, it is likely that differences were due the different sampling methods. Minnow traps were the only method used at other sampling units within each Focus Area during both June sampling events. Since minnow traps are not effective at capturing Sockeye, Chum, or Pink Salmon, we do not know if emergent salmon of these species were present in these sampling units or not. In addition to being ineffective for some species, the minnow traps also had 0.25 inch mesh which newly emergent salmon can freely swim through.

ELH results for FA138 are similar with different methods applied at different sites on different sampling dates. During early May electrofishing was used at the sites sampled, during the first June sampling event, electrofishing, minnow traps, dip nets, snorkeling and fyke nets were only at various sampling stations at different times. No uniform protocol was used. The study failed to identify the locations and habitats selected by fish emerging from 2012 and 2013 adult spawning sites for lack of a consistent and appropriate sampling methodology.

The number of sampling locations and sample timing was improved in 2014. The SIR states that fyke nets were used at all sampling locations, however, catch by method is not provided for 2014, so it is not possible to evaluate the accuracy of this statement. Results also are not provided by date, and fish lengths are not provided so it is not possible to evaluate whether the 2014 data collection will meet study objectives.

NMFS opposes using electrofishing for emergent salmon studies. Electrofishing can cause fry to involuntarily emerge from the gravel and give erroneous results (Figure 4). We have observed salmon fry being pulled from the gravel by electrofishing. Fyke nets and hoop traps with the appropriate mesh size (1/8”) should be used as provided in the approved plan. Minnow traps should be used to augment fyke nets and for the capture of emergent Coho Salmon and Chinook Salmon. This methodology will allow a comparison of catch among stations and sampling dates to meet study objectives.

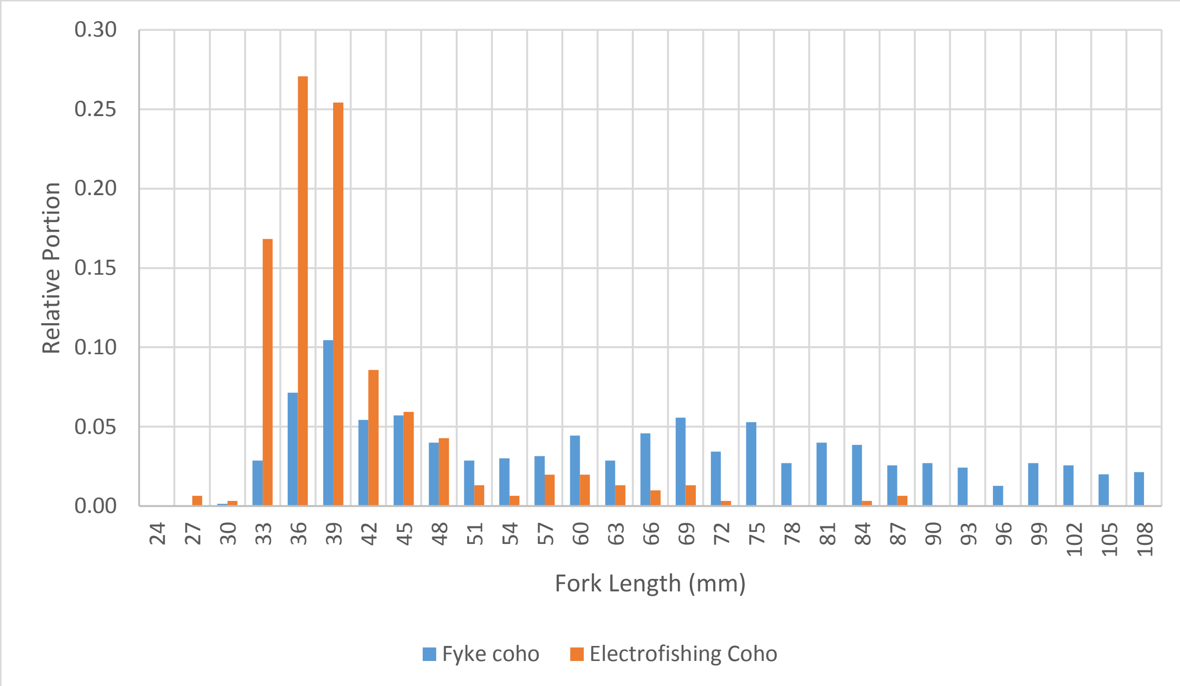

Figure 3. Size frequency distribution of juvenile Coho Salmon captured using fyke nets and electrofishing showing the differences in fish capture from these two methods and the tendency for electrofishing to draw small pre-emergent fry from spawning gravel.

Modification 24: NMFS recommends a study modification adopting AEA's proposal to integrate emergence studies with proposed winter sampling at all Focus Areas prior to breakup, suspending sampling during breakup, and reinitiating sampling following breakup. Bi-weekly sampling should continue until July 1 or until 90% of emergent fry are greater than 50mm fork length. This Modification is further developed in Appendix C.

Modification 25: NMFS recommends a study modification to conduct ELH sampling in the Lower River. NMFS supports AEAs initiative to conduct ELH sampling to determine emergence timing and habitats used by emergent salmon. Sampling should occur proximal to known chum, sockeye, and Coho Salmon spawning locations. This sampling should not replace spring sampling as part of the FDA study.

AEAs RSP and Implementation Plan did not propose ELH sampling within the Lower River. Flow routing studies have documented project effects extending into the Lower River, adult escapement studies have documented chum, Coho Salmon, and sockeye salmon spawning within the Lower River mainstem. Water quality studies have documented differences in water temperature and other water quality parameters in the Lower River compared to the Middle River. Therefore, ELH studies are warranted for this river segment. Limited sampling was conducted in the spring at some locations instead of conducting spring sampling as provided for within the approved study plan.

Results from the adult escapement study (9.7), which was implemented to document salmon spawning locations, can be used to identify 10 Lower River spawning locations. Spawning surveys should be conducted in the second year of study to confirm Lower River mainstem spawning locations used by chum, sockeye, and Coho Salmon (see NMFS study 9.7 comments). ELH bi-weekly sampling from May 1 through June 30, using the methods approved for the Middle River, should be applied to six sampling units adjacent to and downstream from documented spawning locations. Sampling should occur at documented spawning locations and using systematic transects. The proposed ten sampling locations is less than the number of locations sampled by AEA in 2013.

Objective 4: *Documenting winter movements and timing and location of spawning for burbot, humpback whitefish, and round whitefish.*

NMFS does not recommend any modifications to Objective 4.

Objective 5: *Document the age class structure, growth, and condition of juvenile fish by habitat type. (Modification 26)*

Modification 26: NMFS recommends a study modification that clarifies that all fish captured as part of the FDA study be measured to fork length as proposed within the RSP. The first 100 of each species on each sampling date at each sampling location should be weighed to the nearest 0.1 gram. Differences in average lengths and weights over time and among habitats can be an indication of differences in habitat quality. Differences in lengths or weights over time and among locations can be analyzed relative to water quality parameters to determine those variables influencing the growth rates of resident fish and juvenile salmonids. Fork lengths are used to estimate age classes based on size frequency distributions. Length data will allow for comparisons among sampling locations, mesohabitats, macrohabitats, tributaries etc., and allow for calculation of growth as a change in length or weight over time.

AEA did not implement the sampling plan regarding measuring fish lengths and weights as provided for in the approved study plan. Our study modification is intended to clarify the need to obtain fish lengths for all fish and fish weights, with an appropriate precision, on a subsample of fish by species, sampling date, and sampling site.

The number of fish to be measured for length and weight is not clearly identified in the FDAIP. Section 5.1.5 of the FDAIP states that, "each time a gear is sampled, a random sample of 25 individuals per species, life stage, and site will be measured for fork length." The RSP stated that "in conjunction with objectives 1 and 2, all captured fish will be identified to species, measured to the nearest millimeter (mm) fork length, and weighed to the nearest gram" (Section 9.5.4.3.3). The FERC study plan determination summarized the methods described in the RSP stating that all fish would be measured for length and weighed.

It is not clear what methods AEA applied in the field. We are unable to determine the actual number of fish that were measured on each sampling date, location, or by method. The ISR states that AEA randomly measured 25 fish per species and life stage, on each sampling date. It is unclear if fish were only measured during relative abundance surveys or if they were also measured during fish distribution surveys (ISR Part A, Section 4.4). This is considerably different than measuring all fish, or even 25 fish per species per life stage per site.

Fish weights are reported to the nearest gram. Juvenile salmonids may only weigh from 1 to 3 grams. Documenting fish weights to the nearest gram does not provide the precision necessary to evaluate differences in condition factors among sampling locations and therefore application of the methods as in 2013 will not meet the study objective. AEA found a wide variation in fish condition factors. However, this is to be expected when weights are obtained to the nearest gram (i.e. 1,2,3) and at a minimum, weights to the nearest 0.1 should be documented. As most field scales are accurate to this level precision, this modification will require no additional cost or effort.

Objective 6: *Document the seasonal distribution, relative abundance, and habitat associations of invasive species (Northern Pike) (Modification 27).*

Modification 27: NMFS recommends modifying the approved study plan to require the development of a sampling method targeted toward the capture and tagging of northern pike. The distribution of invasive northern pike was not documented. Sampling was not conducted in locations likely to support northern pike (due to transect-based site selection) and few northern pike were radio tagged. The objectives of the approved study will not be met with the approved study methodology. The sampling plan should identify sampling locations, sample timing, and sampling methods directed toward capturing and tagging northern pike. The distribution of pike within the Lower River should be based on their location of capture, movement of tagged fish, and estimated based on physical habitat conditions at captured locations.

Northern pike are invasive to the Susitna River and have resulted in the closure of recreational fisheries in Alexander Creek and severely reduced populations of Coho Salmon, Chinook, and sockeye salmon in other Susitna River tributaries The proposed project will alter Susitna River flows and could increase the vulnerability of juvenile salmon to pike predation and alter habitats in a manner that support northern pike.

The approved study plan relied on incidental capture and radio-tagging of northern pike during sampling events for the FDA study. However, sampling locations based on areas crossed by transects did not result in the selection of sampling locations that were likely to support northern pike. As a result, very few northern pike were captured or tagged. A total of five northern pike were radio-tagged in the Lower River, all captured in a tributary at the most downstream transect (Fish Creek), which drains into Kroto Slough and then into the Yentna River, near its confluence with the Susitna River. All other northern pike observations were made at the mouth of this tributary or in the receiving slough. The study objective is not likely to be met by implementing the same methods during the second year of study. In order to reach tagging goals and to assess distribution patterns, fish should be targeted in other streams identified by ADFG as problem areas, such as Trapper Creek, Rabideux Creek, Caswell Creek, or the Deshka River and additional Susitna River side channels and sloughs.

Objective 7: *Collect tissue samples from juvenile salmon and opportunistically from all resident and non-salmon anadromous fish to support Study 9.14 (fish genetics).*

Modification 9: NMFS recommends a study modification that required tissue samples (belly swab with q-tips) for genetic analyses should be collected from 1 in 10 juvenile salmon to confirm species identification and pre-season field crew training in fish identification regarding juvenile salmon identification.

This is further described under 1-11. While this information is primarily to verify species identification in should be useful in the Fish Genetics Study (Study 7.7).

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Appendix A

Evaluation of sampling methods and site selection to meet Objective 1.

Our comments evaluate the following aspects of data collection for Objective 1: a mathematical context for examining catch per unit of effort (CPUE), from data to estimates, on-site measurements, changes to the list of selected sites and summary comments.

Catch-per-unit-of-effort measurements

Often fishery scientists assume that catch is related to population size, so that catch data can be used to make inference about overall abundance. If catch is denoted C, a measure of effort is denoted E, and the overall abundance is denoted N, then we might assume that there is a catchability coefficient, denoted q, so that $C/E=qN$ (Quinn and Deriso 1999). The basic concept could easily be extended to allow for random sampling error or other more realistic features. If more than one kind of capture technique is used, then E and q will need an index for gear so that $C/E_i=q_iN$, for i denoting capture gear type. In general, $C/E_i\neq q_jN$ when $i\neq j$ and there will need to be well-described statistical methods for comparing catch and abundance when the efforts are not well calibrated.

From data to estimates

For relatively accurate and precise estimates of relative abundance should have a good linear relationship between CPUE of different gears fishing on the same abundance. A poor linear relationship indicates an inaccurate or imprecise measure of abundance in one or both methods. Comparison of CPUE of Arctic grayling by backpack electrofishing and snorkeling (Figure 1, ISR 9.5 2014) results in a highly variable and somewhat ambiguous relationship between the two gears (Appendix C). This suggests poor sampling performance in one or both of the sampling techniques and, therefore, potential problems in the reported data.

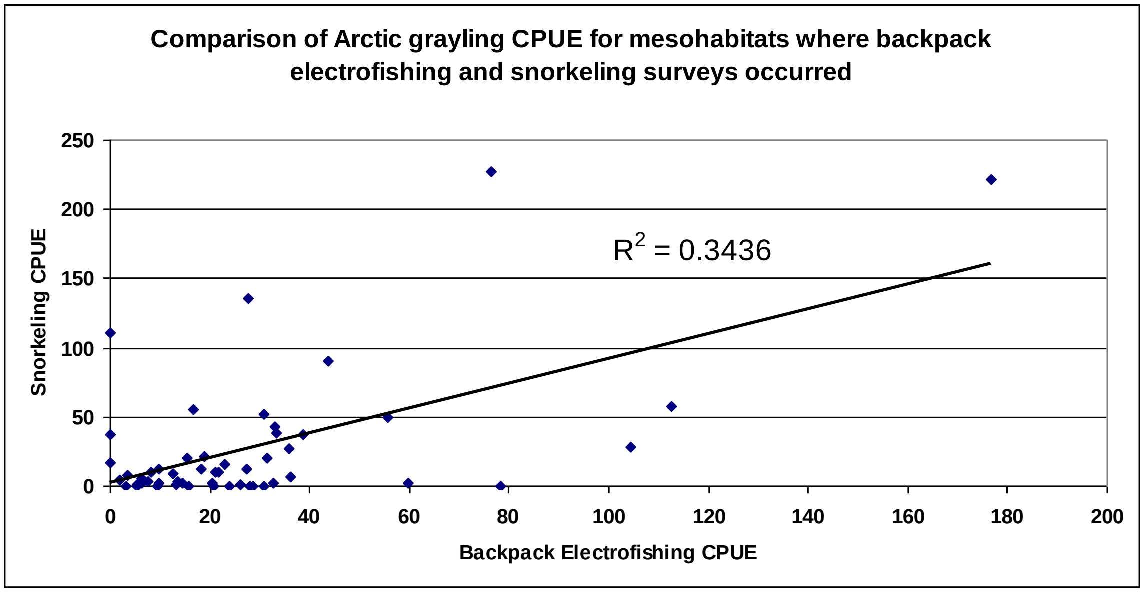

Figure A1. Two CPUE measurements for the same group of mesohabitats in the Upper River.

The calculation of CPUE is also problematic and examination of the results of these calculations indicates more substantial issues. Often, the same site is sampled by multiple gears over one or two days. For example, site TSI_01_04A was sampled by snorkel, backpack electrofishing, angling, and minnow traps over the same two day period in early summer. The estimates of relative abundance for each type of gear would likely depend on the number and order of sampling technique. Dispersal of fish from the survey by snorkel survey or electrofishing is likely to affect catches in minnow traps conducted the same day.

Different sampling techniques measure different abundances. Electrofishing, angling, and snorkeling measure abundance of fish present within the duration of sampling (typically about 1 hour). Minnow trapping and other 24-hour sampling techniques determine abundances over a much longer duration and tend to target smaller and more mobile or migratory species and more crepuscular or nocturnal species.

The CPUE from different gear types is not comparable and cannot be combined to provide a more robust assessment of relative abundance in a given site. Electrofishing CPUE is calculated in fish per hour, seine and snorkel samples are fish per sampled area, and minnow traps, fyke nets and hoop nets are fish per unit of gear. Relative catches would be more comparable if they could be expressed as fish per square meter and relative abundances estimated by either summing or averaging individual gear catches, depending on sampling protocol. This would be similar to past Susitna River sampling programs (Dugan et al. 1984). The efficiency (qi) of each sampling gear type i (described above) varies by species and size of fish, habitat type, and water quality. A number of other studies that have questioned the accuracy of these sampling techniques and the ability to relate the relative catch of one technique to another (Brandner et al. 2013; Hangsleben et al. 2012; Porreca et al. 2013; Nett et al. 2012). The influence of sampling gear selectivity and multiple sampling interactions on relative catch rates makes the quantitative estimate of differences in relative abundance between areas, habitats, gears, and possibly seasons quite challenging.

Some species of fish were found in virtually all sampling sites by at least one sampling techniques (all species combined across all sampling gears). However when individual species and individual gears are examined, fish of a single species were not found (ISR 9.5 2014 Appendix Table D14). For example, juvenile Chinook salmon, burbot, Dolly Varden, longnose sucker, and round whitefish were not found in 95%, 90%, 88%, 93%, and 88% of sites respectively. It is likely that confidence limits on catch and CPUE estimates would include zero for almost all areas and times sampled for these species, and statistical differences or trends in abundance would be almost impossible to measure. Arctic grayling and sculpins were caught in more strata, resulting in more precise assessments of population distributions for these species. An approximation to the coefficient of variation for the Arctic grayling is 206%.

Site selection and substitutions

The distribution and relative abundance sampling was planned using either the GRTS or systematic sampling design protocol. The implementation of the study plan was carried out with few deviations from the plan. The major variance from the sample plan was the reduction in sampling sites. The highly variable nature of this type of sampling requires that a large number of sites be sampled. Analysis of CPUE remains incomplete and qualitative with presence or absence, total counts, and/or selected results from a single sampling event serving to support stated differences in abundance. The FDAIP stated: "Distribution results (i.e. fish observation locations) will be presented on maps. Relative abundance estimates (e.g., fish per unit area, CPUE) within the Lower and Upper River mainstem will be summarized by mainstem habitat type and gear type with appropriate statistical confidence intervals (emphasis added)" (IP 2014). Presence or absence of different species are displayed on maps, generally identifying Upper River fish distributions. Averages and confidence limits are not presented. Averages and estimates of sampling error will be difficult to calculate due to the study design and variability in counts. Subsampling within the GRTS selected sampling sites changes the probability of fish being in a sample, requiring weighting factors in the estimates of means and sampling error measures across transects. Many factors affect catches and CPUE estimates, including location, habitat type, sampling data, sampling technique, and implementation of the sampling procedures. The reported counts are highly variable and each type of sampling gear has its own biases, depending on the habitat type and size and behavior of target species. Quantitative comparisons are statistically challenging and should be performed with a great deal of caution and qualifications reported. However, some results can be supported with more elaborate data analysis and even qualitative data can be possibly compared using non-parametric statistical techniques or computer simulation. The study did qualitatively suggest which capture techniques are most effective for each species. Paired comparisons of sampling techniques could also be used to determine the best tactics.

Results discussed in habitat associations (section 5.1.3) could be an outcome of the susceptibility of different species to different sampling gear. This gear-species interaction could be evaluated by testing mesohabitat associations across all sampling techniques and across different macrohabitats by ranking mesohabitats by abundance for each sampling technique or for each habitat type. Estimates of confidence limits on the relative abundance estimates would determine if estimates by mesohabitat type are significantly different from zero.

Samples may be biased by removal or harassment of fish in the same sampling site before subsequent sampling using another sampling technique on the same day. Each sampling technique has its biases, depending on habitat type, fish size, and fish behavior. For example, the disturbance of fish by snorkelers swimming through a habitat will likely affect the abundance and distribution of fish vulnerable to successive electrofishing or seining operations. Samples are categorized by geomorphic reach, sampling date, sampling site, macrohabitat type, mesohabitat type, and sampling technique, all of which may impact the abundance of different species and interact with each other. Arriving at defensible quantitative conclusions about the relative importance of any single factor to the abundance of any fish resource is difficult and require careful consideration of the effect of all other factors. However the data provide good qualitative information on selection of sampling sites that might serve as long term monitoring sites, on what sampling techniques are most appropriate for each habitat type, and on selection of future sampling plans. Table 5.1-3 in the ISR indicates that electrofishing is the most effective means of recording the presence of fish, followed by snorkeling. Minnow traps were also effective for smaller fish.

The failure to sample four mainstem transects reduces information on species composition in the upper reaches of the Susitna River. Seasonal sampling was also incomplete. Ad-hoc adjustments to sampling protocol are warranted when strict adherence to a sampling plan might jeopardize safety or the achievement of larger sampling goals. There might also be times when following the sampling plan is simply impossible because of land-access limitations, safety concerns, and logistic limitations. But the ad-hoc adjustments to the sampling protocol limit the ability to inform the decision process. Sampling needs to strictly follow a valid sampling plan unless there is a very compelling reason not to. Moreover, that sampling plan should closely link sampling unit selection, data collection, and parameter (and sampling error) estimation, and the analysis of those estimates to reach conclusion.

Recommendations for Objective 1:

1. Before any further sampling is done, gear effectiveness needs to be evaluated, and then only specific gears that do not conflict with each other (by harassing or dispersing fish before the next gear is used) should be used at each site.
2. The study plan should be expanded to include a description of how the various data will be turned into quantitative estimates so that rigorous comparisons can be made across species, across river habitat types, and across time.
3. The sampling plan should be reevaluated so that there is a tight linkage between the sampling design and the estimates and statistical inferences that will be drawn from the data.
4. Estimates should be presented with appropriate measures of sampling error (confidence intervals or standard errors).

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Appendix B

Chinook salmon identification

Objectives 1, 2, 3, 5 and 7

Data presented by the AEA as part of the initial study report (ISR) 9.6 (FERC P-14241-000), Middle and Lower River FDA, and ISR 9.6 presentation posted on October 1, 2014, shows that juvenile[1] salmon reported were incorrectly identified as Chinook Salmon. This has significant implications for describing the ELH, distribution and abundance, habitat associations, growth rates, movement patterns, and food preferences from juvenile salmon. The 2013 field data cannot be relied on to address the objectives of these studies.

The basis for the determination that Chinook Salmon juveniles were misidentified are (1) reported habitat associations, (2) misunderstanding of identifying characteristics as shown in the ISR 9.6 presentation (slides 8, 9 and 10), and (3) reported Chinook Salmon fork lengths that are inconsistent with other studies and fork lengths and exceed those of a species that spends one year in fresh water.

Habitat Associations

The habitat relationships of Chinook Salmon presented by AEA in the ISRs suggest that Chinook and Coho Salmon were misidentified. The ISR states that juvenile Chinook Salmon counts were highest in upland sloughs and these counts were highest in slow water beaver –complex mesohabitats. For example, based on a review of data provided, 51 Chinook salmon juveniles were captured in the beaver pond complex of Slough 6A (FA 115), and one Chinook salmon juvenile was captured in the backwater pool downstream from the beaver dam. High numbers of juvenile Chinook (292) also were reported for the Upland Slough beaver pond complex in the Indian River Focus Area (FA 141). These findings are inconsistent with previous studies of juvenile Chinook salmon that generally document juvenile Chinook preference for habitats with high water velocities (with the exception of newly emergent fry) and dissolved oxygen, whereas, Coho Salmon salmon have a greater tolerance for higher water temperature and low dissolved oxygen levels, and are most abundant in upland sloughs and beaver ponds.

During the 1980s Susitna studies found that juvenile Chinook salmon relative abundance was lowest in upland sloughs (ADFG 1983) and highest in side channels and side sloughs. Juvenile Coho Salmon salmon tend to occupy slower waters such as upland sloughs, beaver complexes, and wetland streams. Murphy et al, (1989) found that Coho Salmon in the glacial Taku River occupied habitats with significantly slower currents than Chinook and that Chinook were “virtually absent (mean <1 fish/100 m^2) from beaver ponds and upland sloughs.”

Chinook salmon are more temperature and oxygen sensitive and are most often found in fast-flowing, highly oxygenated, cold water habitats (Murphy et al, 1989; Quinn, 2005; Richter and Kolmes, 2005). Beaver ponds have relatively higher temperatures and lower dissolved oxygen

[11] Juvenile refers to the life stage from emergence through freshwater residency until smoltification and emigration.

than other mesohabitats (Collen and Gibson 2001). Davis (1975) reports that freshwater salmonids begin to show distress at dissolved oxygen levels of 6.0 mg/L and that most fish are affected by lack of oxygen at 4.25 mg/L. Through extensive experimental work, Whitmore et al (1963) determined that juvenile Chinook salmon will avoid waters with dissolved oxygen levels less than or equal to 4.5 mg/L and that adult Chinook will not migrate through waters with dissolved oxygen levels less than 3.4 mg/L. Eddy (1971) contends that Chinook salmon have a low tolerance for temperature and dissolved oxygen fluctuation, stating that at temperatures greater than 12°C, all dissolved oxygen levels lower than air-saturation levels significantly reduced survival. In contrast, past studies record Coho Salmon salmon successfully rearing in low dissolved oxygen environments, even below literature lethal values, suggesting that they have a greater tolerance for low dissolved oxygen levels (Henning et al, 2006). These previous studies indicate the unlikelihood of finding an abundance of Chinook salmon in beaver pond complex habitats.

Species Identifying Characteristics

The photograph of a juvenile Coho Salmon salmon provided as part of the ISR 9.6 presentation posted by AEA demonstrates a misunderstanding of the characteristics used to identify juvenile salmon (Figure 1). The key used by the Alaska Department of Fish and Game, Division of Habitat and Restoration is Trautman (1973), “A guide to the collection and identification of presmolt Pacific salmon in Alaska with an illustrated key.” This NOAA technical report (attached) provides a dichotomous key to juvenile salmon identification. In this key, the following characteristics are used to separate Chinook salmon from Coho Salmon salmon.

5a. [Chinook salmon] Combination of: Melanophores on adipose fin usually most numerous on posterior half and generally forming a dark border (see Plate 4); anterior half of adipose with few melanophores or none. Anal fin with few melanophores or none, but when melanophores are present, often quite large. Tip of dorsal fin and lobes of caudal fin darker in larger presmolt juveniles.

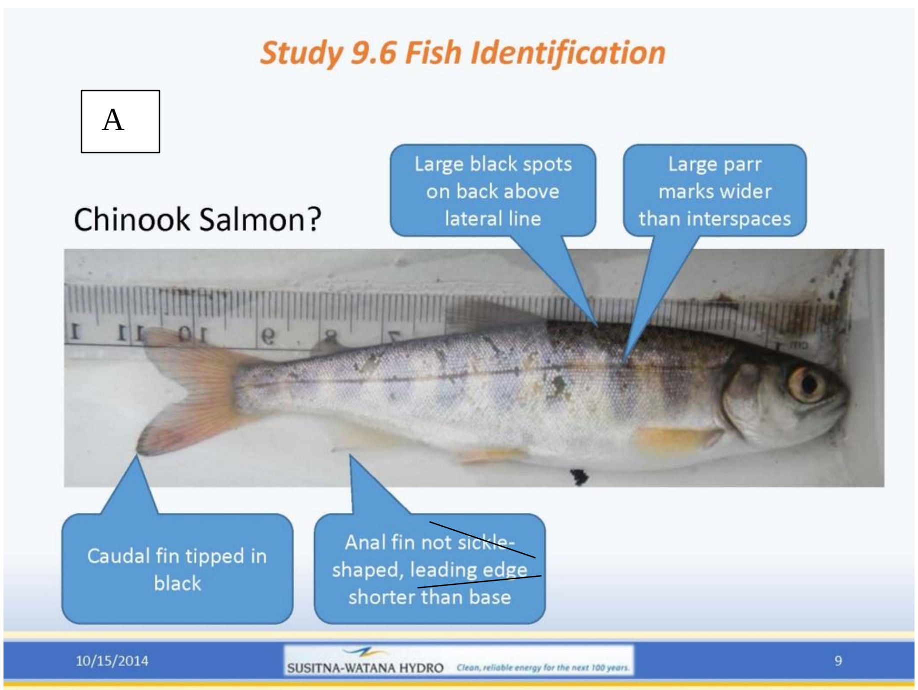
Review of the Coho Salmon salmon in Figure 1A (posted by AEA in presentation 9.6) shows that melanophores are present throughout the adipose fin and anal fin confirming that it is not a Chinook salmon. In comparison, melanophores are absent from the anterior adipose and anal fin of fish shown in Figure 1B in this report, which we captured in Slough 6A confirming that it is a Chinook salmon.

For Coho Salmon salmon Trautman states:

5b. [Coho salmon] Combination of: Melanophores usually numerous and rather evenly distributed on adipose fin; occasionally in larger juveniles, posterior or free edge may be darker than remainder, thereby resembling somewhat melanophore distribution on adipose of Chinook salmon. Anal fin in specimens larger than 30 mm FL more falcate and anterior tip more pronounced than in other species, including chinook salmon; in all except smallest specimens, anterior or leading edge of anal fin is whitish, with a dark bar parallel and posterior to it; remaining, posterior portion of fin usually abundantly speckled with melanophores except for distal and posterior edges (see Plate 5).

Melanophores on the adipose and anal fins confirm that the fish in 1A is a Coho Salmon salmon. The presence of the dark bar and falcate anal fin of the fish in figure 1A provides further support to the initial classification. The lack of pigment within the anterior adipose fin to distinguish between Chinook and Coho Salmon juveniles builds upon previous studies (Dahl and Phinney 1967).

The documents cited by AEA in the FDAIP to assist in field identification are, "Field Identification of Coastal Juvenile Salmonids" by Pollard et al. (1997) and "Juvenile Salmonid and Small Fish Identification Guide" by Wiess (2003). These are good photographic-based field guides, based on Trautman (1973) that provide some additional characteristics that can support initial findings, but should not be used to replace the NOAA technical report. In Figure 1A AEA references a "sickle shaped anal fin," and "large black spots on back." Trautman refers to the sickle shape, as a falcate and pronounced anterior tip of the anal fin. This characteristic is present in Figure 1A, although it was not recognized by AEA. The sickle shaped or falcate anal fin is less pronounced in older Coho Salmon salmon similar to the 100 mm specimen shown in 1A. Trautman also refers to the large spots between the dorsal ridge and parr marks on Chinook salmon. These are evident in Figure 1B. AEA misinterprets this to refer to the ubiquitous spotting along the dorsal surface of juvenile Coho Salmon salmon (see AEA note in figure 1A) which are not "large black spots." Trautman also references the greater contrast between the parr marks and underlying surface in Chinook salmon (brighter silver appearance) when compared to Coho Salmon salmon.



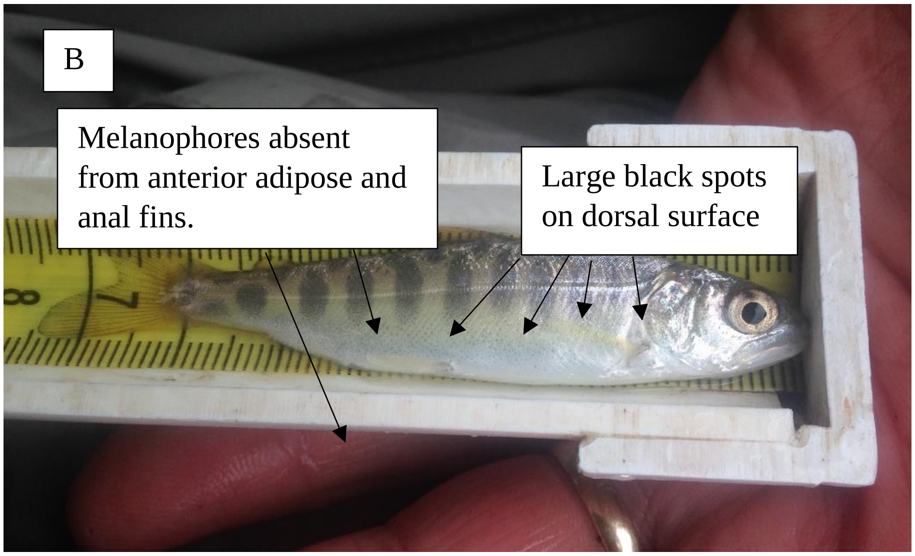


Figure 1. Panel A is a photograph of a Coho Salmon salmon provided by AEA as part of the ISR 9.6 presentation. Blue callouts were provided by AEA to point out classification characteristics they believe support classification as Chinook salmon. Panel B is a photograph of a Chinook salmon we collected from Slough 6A. In Figure 1A note the melanophores throughout the adipose and anal fins, sickle shaped anal fin, black stripe on anal fin and absence of large black spots on the dorsal surface. In Figure 1B note the differences in the pigmentation of the adipose and anal fins; presentation of large black spots, and lack of black band on anal fin. The parr marks on the Chinook salmon are generally wider than the space between parr marks, when compared to Coho Salmon salmon, particularly smaller (55 to 65 mm) specimens; however, this is not a good field characteristic as the parr marks on larger Coho Salmon tend to increase with fish size.

Fork Lengths

Fork length data for fish identified as Chinook salmon are too large for a fish species that spends one year in fresh water and are inconsistent with juvenile Chinook lengths measured other studies in the Susitna River and other nearby locations.

Scale pattern analysis has confirmed that Chinook salmon in the Susitna River drainage spend one year in fresh water (ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985, Thompson et al. 1986 as cited by R2 Resources 2013). Coho salmon rear for 2 or 3 years in freshwater, with about 50 to 60 percent outmigrating to the ocean during their third year of life and 30 to 45 percent outmigrating during their second year of life (ADF&G 1981, ADF&G 1982c, ADF&G 1984, Barrett et al. 1985, Thompson et al. 1986 per R2 Resources 2013)."

The size distribution of Chinook salmon during the one year in freshwater are available from multiple sources. Previous studies conducted by ADFG (1983) in the Susitna River document a mean fork length range from ~ 50 to 70 mm (Figure 2). During June and July some age 1

Chinook are present with longer fork lengths, with a maximum of 125 reported by ADFG. Kirsch et al. (2014) also found the mean fork length of Chinook salmon to range between 50 and 60 mm. The size distribution of Chinook salmon within the Susitna River collected by ARRI as part of a study supported by the NMFS from October 2013 to February 2014 (Davis et al. 2013) is consistent with these values (Figure 3). This size range also is consistent with the fork lengths obtained from over 7,000 Chinook salmon captured by ARRI within the Susitna River drainage from 2007 through 2013 (Figure 3).

The size distribution for Chinook salmon reported by AEA is inconsistent with these studies. The size distribution of Chinook salmon as reported by AEA is shown in Figure 4 (fork lengths obtained from ISR_9_5_FDAUP_FishCondFactors, and ISR_9_5_FDAUP_PITTagData). The mean size of juvenile Chinook salmon captured by AEA is 93 mm with a range of 50 to 200 mm (n = 647). This mean size is 30 mm greater than the fork lengths reported from other studies. Figure 5 is a comparison between the size distribution of Chinook salmon captured by ARRI within the Susitna River drainage, which is consistent with studies conducted by ADFG, and the size distribution of fish reported by AEA to be Chinook salmon. It is evident from this figure that these fish are not from the same population. The size distribution of fish reported by AEA does not contain and age-0 age class. We conclude that based on the fork lengths of the fish reported by AEA for Chinook salmon, are not Chinook salmon, but are more likely Coho Salmon salmon (Figure 5).

AEA has reported habitat associations of Chinook salmon juveniles that are inconsistent with other studies. They have demonstrated a lack of understanding of the morphological characteristics that are used to differentiate juvenile Chinook from Coho Salmon salmon. The fork lengths of Chinook salmon reported by AEA do not represent a species that spends one year rearing in fresh water and are inconsistent with other studies. AEA Study 9.6 results from fish reported by AEA as representative of Chinook salmon juvenile distribution, abundance, movement patterns from PIT tags, growth, and habitat associations should be discarded.

Table E.3.1.11. Chinook salmon juveniles, age - length frequency at habitat location sites on the Susitna River between Talkeetna and Devil Canyon, June to September, 1981.

	Age 0+			Age 1+		
Date	Number of Fish	Mean Length (mm)	Range of Length (mm)	Number of Fish	Mean Length (mm)	Range of Length (mm)
June 1-15	6	50.7	40-63	13	90.2	78-105
June 16-30	5	45.8	32-60	19	92.0	80-108
July 1-15	49	52.0	39-76	5	92.2	88-96
July 16-31	93	55.6	42-78	1	91	-
Aug. 1-15	225	57.7	43-84	0	-	-
Aug. 16-31	336	62.0	41-94	0	-	-
Sept. 1-15	228	64.9	47-93	0	-	-
Sept. 16-30	471	67.0	42-108	0	-	-

Table 3-3-27 Chinook salmon juveniles, mean length and range of lengths by age class between the Chulitna River confluence and Devil Canyon, May to October, 1982.

	Age 0+			Age 1+		
Date	Number of Fish	Mean Length (mm)	Range of Lengths (mm)	Number of Fish	Mean Length (mm)	Range of Lengths (mm)
May 16-31	0	-	-	2	90	85-95
June 1-15	1	40	40	38	84	68-100
June 16-30	19	49	34-70	142	89	71-125
July 1-15	67	55	36-74	63	92	76-115
July 16-31	139	54	36-77	17	90	83-108
August 1-15	84	61	39-88	1	117	117
Aug. 16-31	65	64	42-94	0	-	-
Sept. 1-15	100	69	41-95	0	-	-
Sept. 16-30	41	69	47-100	0	-	-
Oct. 1-12	1	80	80	0	-	-

Figure B2. Fork lengths of Chinook salmon juveniles by time period (ADFG 1983) showing the size distribution of Chinook salmon juveniles in the Susitna River.

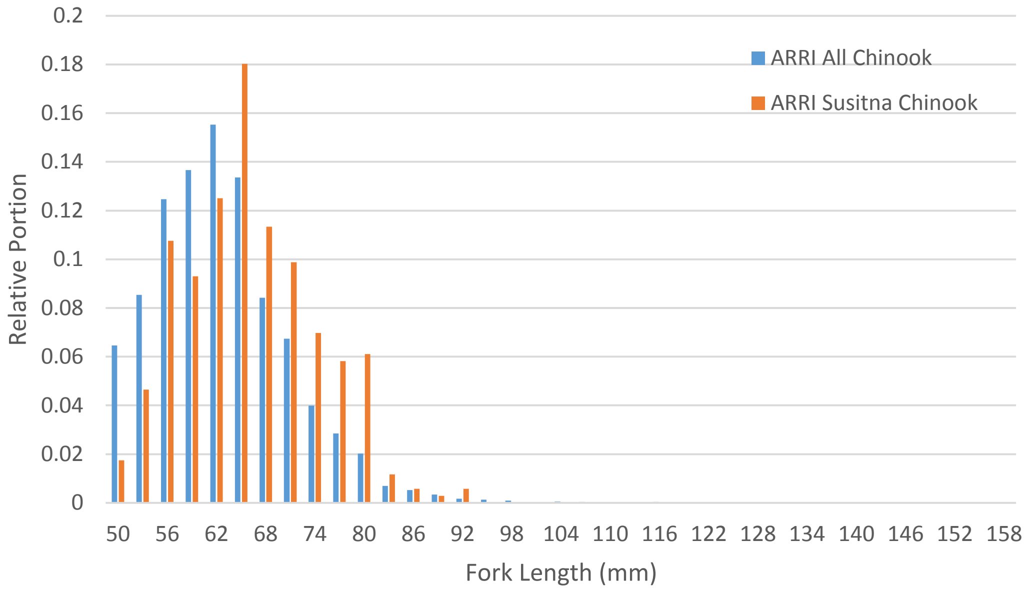


Figure B3. Size distribution on Chinook salmon from samples collected by ARRI throughout the Susitna River basin from 2007 through 2013 (n = 7,434) and Chinook salmon captured in the Middle Susitna River during the winter of 2013/2014 (n = 344). The larger size in winter reflects summer growth. This size distribution is consistent with other studies conducted by ADFG.

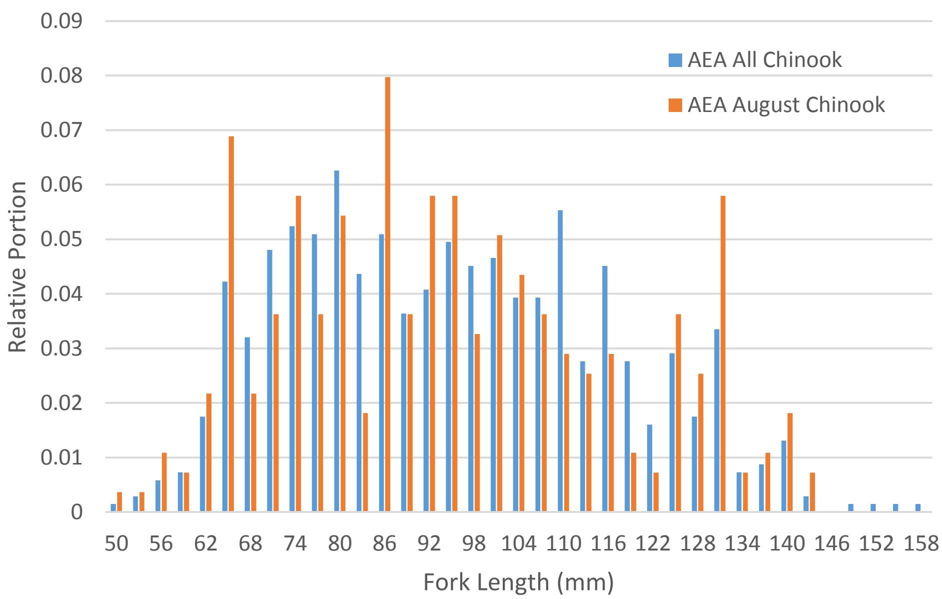


Figure B4. Size distribution of fish reported by AEA to be Chinook salmon from FDA studies. Data are plotted for August - September, and for all months (n = 647). Mean fork length is 93 mm with lengths ranging up to 143 mm which is inconsistent with other studies.

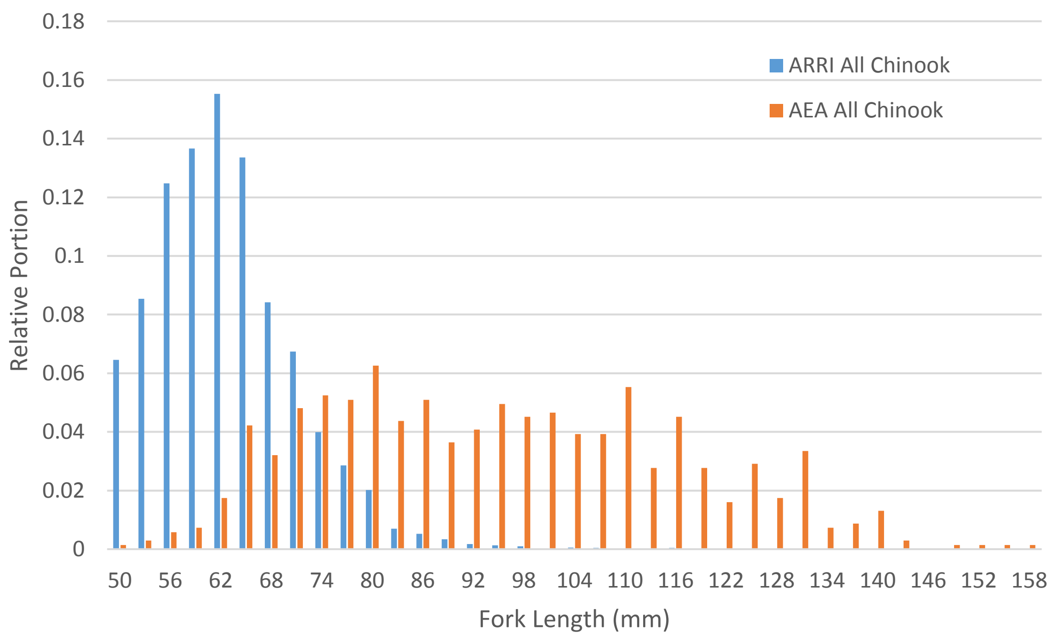


Figure B5. Comparison of the size distribution of Chinook salmon from the Susitna River drainage collected by ARRI with those reported by AEA showing the large difference in the size distributions. ARRI's data is unimodal representing a single age class which is consistent with the life history of this species, and the size range is consistent with other studies.

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Appendix C

Comments on AEA's 2013-2014 Winter Fish Study Technical Memorandum

Objectives 1, 2, 3, 5 and 7

Summary

The objective of determining juvenile salmon overwintering habitat associations has not been accomplished due to problems with habitat classification and site selection, inconsistent sample collection methodology, low or no replicate sampling of macrohabitats, and absence of measures of habitat characteristics. Quantitative juvenile salmon overwintering data are only provided for 2 to 3 replicates of a subset of the Susitna River macrohabitats and no data are provided for the remaining macrohabitat classes. Data from these sites are not representative of the fuapproximately 50 miles of Middle River and 100 Lower River miles of fish habitat. In addition, some macrohabitats are misclassified and sampling sites in others are not representative due to dominant mesohabitat characteristics (e.g. in beaver ponds). Tributary mouths and main channel habitats were not sampled. Independent analyses show that differences in macrohabitat catch per unit effort (CPUE) for Chinook and Coho Salmon salmon juveniles were not statistically significant among macrohabitats during February or March. No measures or descriptions of habitat characteristics are provided. The study has shown that juvenile Chinook, Coho Salmon, and sockeye salmon overwinter in off-channel Middle River habitats. However, due to inaccurate macrohabitat classification, the low number of replicates, and inconsistent sampling methods, this study is unable to determine if there are significant differences in juvenile salmon abundance among the 3 macrohabitats investigated. There is no information for two of the five Susitna River macrohabitats (main channel and tributary mouth) and no information on the habitat characteristics within or among those habitats investigated.

The radiotelemetry study was developed to answer some basic questions regarding resident fish species overwintering habitat and habitat characteristics. For those species that likely aggregate spawn within the main channel or off-channel habitats (burbot and whitefish), determining the timing, locations, and spawning habitat characteristics was of primary importance. For other resident fish (i.e. rainbow trout, grayling, Dolly Varden, lamprey), the study was developed to understand when fish moved from tributaries into and out of the Susitna River mainstem for spawning and overwintering, and to identify mainstem overwintering locations and habitat characteristics (water depths, velocities, ice cover, etc.). This Technical Memorandum summarizes the first winter study results. It does not provide information to address these questions.

The inability to meet radiotelemetry study objectives is the result of incomplete study implementation. The number of tagged fish at the start of winter was well below target levels of 30 fish within each river segment. Tagged fish were not tracked by snow machine or foot to determine their location at a scale that could be used to identify spawning or overwintering by macrohabitat or habitat characteristics. Therefore, timing of movement into the Susitna River for overwintering or out of the Susitna River for spawning is not known. There is no information on specific overwintering macrohabitat locations, or habitat characteristics selected by overwintering fish.

The detection of PIT-tagged resident fish and juvenile salmon documented juvenile Coho Salmon and Chinook salmon migrating from spawning tributaries (Indian River) and the Susitna River main channel to off-channel overwintering habitats. The study does not provide any additional information regarding juvenile salmon and resident fish movement. The study did not report the total number of fish tagged within a macrohabitat or the detection efficiency of stationary antennas; therefore, the study was unable to document the portion of tagged fish moving into or out of a Focus Area. Because a single antenna was used one could not determine whether a fish moved across an antennae or only approached the antennae and if it crossed an array, whether the fish migrated outside of the macrohabitat or Focus Area. No data are provided on when fish were tagged or when fish were detected. The study is unable to determine if movements were associated with any habitat variables (i.e. change in velocity or water depth) or the timing of smolt movement.

Similar problems are associated with the interpretation of the recaptured PIT-tagged fish. Only a small portion of the tagged fish were recaptured, which could be due to low probability of recapture of fish or due to a large portion of the fish migrating from the site. The fact that 50% of the recaptured fish occurred at the location where fish were tagged is not an indication of site fidelity due to low number of recaptures and differences in capture probability. Since sampling did not occur outside of the Focus Areas where they were tagged it is not possible that tagged fish would be recaptured elsewhere.

Juvenile salmon growth rates were included as a winter study objective in order to provide a metric that could be used to evaluate differences in overwintering habitat quality. Due to the low number of recaptured PIT-tagged salmon, there were not enough replicates to test for differences in growth among the three macrohabitats investigated (side sloughs, upland sloughs, and side channels). Due to the low number of recaptured fish measured, growth of individual fish may not be representative of the fish population. Growth rates were variable over time and the time period that growth was measured for each tagged fish was inconsistent. Some of the differences in growth reflected differences due to when the fish were tagged and not differences among macrohabitats. Differences in growth, where present, also are not likely to be representative of the macrohabitat due to the low number of replicate macrohabitats (2 to 3) where growth was measured.

The detection of differences in age classes of juvenile salmon among macrohabitats will not be accomplished by plotting length frequency distributions at 10 cm intervals with the exception of identifying newly emergent fish. The low number of replicate macrohabitats and low number of fish captured during winter months, and combining fish collected from November through April reduces the likelihood of detecting differences in condition factors among macrohabitats.

Overwintering Habitat Associations

Sample Timing

Only samples collected during February and March should be used to assess winter habitat associations of juvenile salmon and resident fish. Sampling was conducted in November, February, March, and April. November sampling is prior to ice development and does not reflect winter conditions. The formation of ice significantly alters water depths and velocities among macrohabitats. Conditions are fairly stable from December following ice development through March. During April, breakup has started with an open mainstem channel which reduced stage height in off-channel habitats (Figure 1).

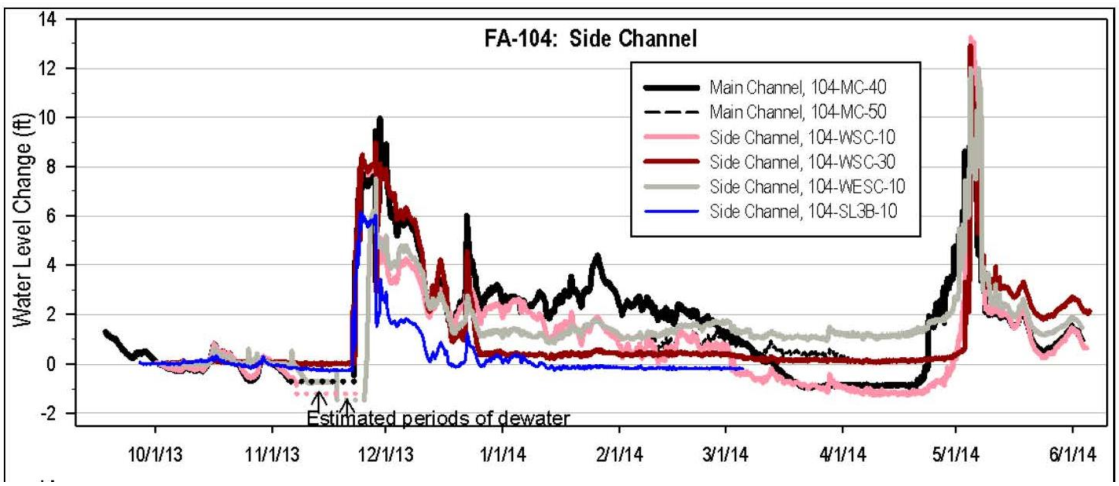

Figure C1. Change in water surface elevations in the main channel and side channels beginning in March of 2014. Figure 3 of AEA 2013/2014 IFS Winter Technical Memorandum.

Sampling Locations

Sampling site locations were not representative of the macrohabitats under investigation and contained very few replicates during the winter months. During February and March there was only one side channel habitat sampling site in FA 104 (WFS 104 154). This is inconsistent with the Technical Memorandum that states three replicates GRTS sites were selected for each macrohabitat types in each Focus Area. The FA 104 sampling locations, while identified in AEA Table 5.1-7 as a side channel is contradicted by side slough designation in AEA Figure 3.1. We support the side slough habitat classification based upon the review of aerial imagery. Therefore, no side channel habitats were sampled in FA-104. The two sites classified as side sloughs are misclassified and are located in the mouth of Whiskers Creek, downstream of where the Creek discharges into side slough habitat. ARRI sampled both of these locations during the winter of 2012/2013 and found significantly higher relative abundance of Chinook and Coho Salmon salmon within the side slough upstream of the tributary discharge point than downstream in the tributary mouth where AEA sampled (Davis et al. 2014). AEA also sampled further upstream within Whiskers Creek; however, as tributaries are not one of the Middle River macrohabitats under investigation, these sites do not address the study objective. For FA-104, therefore, only one side slough, two tributary mouth, and three upland slough sites were sampled representing one side slough and one upland slough that can be used to address the study objectives. The classification used in the current study reduces the likelihood of furthering our understanding of macrohabitats used by overwintering salmonids.

In FA 128, one side channel site was sampled with minnow traps in February and March (WFS-128-64), and one additional side channel site was sampled by electrofishing in February (WO 119). The second side channel site crosses an island. These ephemeral channels should not be classified or sampled as representative of mainstem macrohabitats. The single island side channel site was not sampled in November. It is not known if fish were present at this location prior to ice development. Three side slough habitat sites were sampled by AEA in February and March, all representative of the same side slough. The sites were at the upstream end of the side slough within a beaver complex and outside of the Focus Area. These sites are representative of side sloughs; however, the associated beaver complex will ameliorate changes to water depth and velocity as the upstream end of the slough is breached during ice formation and mid-winter ice jams. Three upland slough sites were sampled in FA 128 during February and March. All three of these sites also are on a mid-channel island and one of the sites is superimposed by side channel habitat (see AEA Figure 3-2).

Within FA 138, two side channel habitats units were sampled in February and March. Two upland slough units were sampled; however, one of these sites (Site 76) is more accurately classified as a side slough. The slough habitats sampled represent a single side slough, but also were within beaver complex mesohabitats.

In summary, four side channel sites were sampled in February and three in March representing three distinct side channels, one of which was located on an island. Seven side slough sites were sampled in February and March representing three distinct side sloughs. Six of these sites were within beaver complex mesohabitats. Seven upland sloughs were sampled in February and March, representing four distinct upland sloughs, with three of the sloughs located on an island and with one of the sloughs more representative of a side slough than an upland slough.

Sampling Effort by Method

Fish collection methods were not consistently applied at all sampling locations and sampling dates, results from different methods cannot be combined, and sampling unit lengths for each method and date are unknown. Minnow trap data are the only sampling method that was used on all sampling dates at most sampling sites. Therefore, minnow trap data are the only sampling method that can be used to test for differences in the relative abundance of juvenile Chinook and Coho Salmon salmon among sites during winter sampling (February and March). AEA Tables 5.1-1 through 5.1-12 show that in FA 104 during February and March, fyke nets and electrofishing were only used in one macrohabitat type (excluding Whiskers Creek which is not a habitat under consideration). In FA 128 fyke nets were not used in February and at only one macrohabitat type in March, and electrofishing was used in three macrohabitat types in February and two macrohabitat types in March. Fyke nets were not used in FA 138 during February or March and electrofishing was used in two macrohabitats during both months. In addition, since fyke nets and electrofishing can only be used in open leads, results from these methods only represent a subset of available winter habitats. Therefore, there are not replicate sampling units using these methods to provide for comparisons among macrohabitat or over time.

Data Analyses and Results

AEA's analyses in section 5.1 of the Technical Memorandum provides a summary of the CPUE data from AEA Tables 5.1. The analysis does not test for differences among macrohabitats using comparable February and March data. For example, Chinook catch is reported as highest in tributary habitat. Fyke net catch is reported by AEA for FA 104 tributary habitat, but the report fails to mention that this method was not used in any of the other FA 104 macrohabitats or that high catch included a large number of emergent fry in April. Therefore it appears that high abundance in tributaries is due to the capture of large numbers of emergent fry with a collection method not used in other sampling locations. Using AEA's minnow trap data, in February average Chinook catch per unit trap (CPUT) was 0.11 in upland sloughs. 0.18 in side sloughs, and 0.00 in side channels; however, differences were not significant (ANOVA $p = 0.48$). There also was no differences in March Chinook CPUT among macrohabitats with means of 0.03, 0.00, and 0.02 for upland sloughs, side sloughs, and side channels, respectively.

For Coho Salmon salmon juveniles average February CPUT was 0.63 in upland sloughs, 0.41 in side sloughs, and 0.66 in side channels, with no significant differences among macrohabitats ($p = 0.83$). If you exclude the low catch from FA 128 mid-island upland sloughs, average February Coho Salmon CPUT from upland sloughs is considerably higher at 4.26. No Coho Salmon salmon were captured at the FA 128 island side channel site in February or March. March average Coho Salmon CPUT was 0.69 in upland sloughs, 0.25 in side sloughs, and 0.27 in side channels; however, averages were not significantly different ($p = 0.45$). If the island upland sloughs of FA 128 were excluded March Coho Salmon average CPUT would have been considerable higher at 5.51 in upland slough macrohabitats. Therefore, including mid-island upland sloughs resulted in no significant differences, while excluding these sites resulted in Coho Salmon CPUT significantly higher in upland slough macrohabitats ($p<0.05$). This analysis indicates that mid or cross-island habitats are biologically distinct and should have a unique classification, and suggest that Coho Salmon are more abundant in upland sloughs during winter.

Habitat Characteristics

Habitats under investigation do not have associated descriptions. Habitat variables (water depth, velocity, cover, ice thickness, wood debris, substrate type, dissolved oxygen, pH, and specific conductivity) should be measured to evaluate important characteristics for overwintering salmon. This is particularly important if the IFS is unable to capture enough fish to develop habitat suitability curves (HSC) or accurately model water depths and velocities in Focus Areas.

Winter Movements

The radio tagging study was not implemented as provided for in the approved plan and there are not enough tagged fish to come to any conclusions regarding juvenile salmon and resident fish winter movements or habitat use during the winter months. Tagged fish were not tracked to specific locations, the area describing fish locations were very large, and there is no information on the habitat characteristics selected during winter by tagged fish. Therefore, the study does not provide the information necessary to evaluate or mitigate for potential project effects.

The technical memorandum exaggerates the number of tagged fish tracked during winter. Due to the low number of tagged fish it is not clear what portion of the population is represented. For example, Section 5.2.1.1.1 states that 10 tagged Arctic grayling were released upstream from Devils Canyon and 6 below; however, the TM does not report that, per AEA Table 4.5-1, of the 10 tagged Arctic grayling only 6 were active by January 1 and only 3 by January 15. Similarly, of the 6 tagged Arctic grayling below Devils Canyon only 4 tagged fish were present by December 1. The movements of 4 Arctic grayling cannot be expected to be representative of the Middle River Arctic grayling population. Information on the movement of Upper River Arctic grayling described in the TM is not supported by information in the cited table (AEA Table 4.5-8), that shows the locations of approximately 11 Upper River Arctic grayling and not the 31 referenced in the report. The locations of the Arctic grayling in the Tyone River are not shown in the referenced table. The TM fails to describe two Arctic grayling that were released near Kosina Creek and were later located below Devils Canyon near Lane Creek, and apparently migrated back upstream (AEA Table 4.5-8).

The approved study plan stated that tagged fish would be tracked by snow machine and foot to determine overwintering locations. However, as this study was not implemented as proposed, there is no information on Arctic grayling overwintering habitats. The TM states that the Arctic grayling released near Lane Creek remained between Montana Creek (PRM 80.7) and the Gateway (PRM 130), or somewhere within 50 river miles. Looking closer at Table 4.5-1 only narrows this down to 8 to 15 river mile sections. If detailed information is available it is not provided. The study does not determine if these fish overwintered in main channel habitats, tributary mouths, or in off-channel habitats. The water depths, ice cover, and water velocities of overwintering locations are unknown and will not be available unless tagged fish are tracked to overwintering locations by snow machine or by foot as described in the approved study plan.

AEA Table 4.5-2 shows the movement of 2 burbot, not the 6 or 3 as described in the TM. One of these fish overwintered somewhere between mile 88 and 102 and the other fish overwintered between mile 102 and 117. Therefore these two fish could have been at the same location, near mile 102 or approximately 30 miles apart. Table 4.5-9 does not show the location of any tagged burbot in the Upper River to support descriptions in the TM.

AEA Table 4.5-3 shows that no tagged Dolly Varden were tracked in the Middle or Upper River during winter. Only 2 longnose suckers were tracked in the Middle River and none past February.

On January 15, 19 tagged rainbow trout were detected in the Middle River as opposed to the 21 referenced in the TM. The TM states that most rainbow trout showed minimal movement between zones; however, according to AEA Table 4.5-6, 2 or 3 of the 4 rainbow trout tagged near Montana Creek moved into the Sunshine to Talkeetna zone. The TM states that the only tributaries used by rainbow trout were the Chulitna and Talkeetna Rivers; however, of the 8 fish released in the Talkeetna River only one or two fish were ever detected again, none of these rainbow trout were detected in the Talkeetna River, and only 1 fish was detected in the Chulitna

River (AEA Table 4.5-6). This is also inconsistent with the PIT tag data that reports 3 rainbow trout at Whiskers Creek, one of which migrated downstream from the Indian River. Based on AEA's Table 4.5-6, five to six of the 13 tagged rainbow trout overwintered in the Sunshine to Talkeetna or Talkeetna to Lane zones, regardless of where they were released. It would be useful (and necessary) to know where within this large area these fish were located, the habitat characteristics of this location, and whether project operations could affect rainbow trout overwintering habitat.

The TM provides no specific information on overwintering habitat of round whitefish which were located between PRM 88 and PRM 140 (52 river miles) and also through the rest of the Susitna River from the Deshka River to Sunshine (TM Section 5.2.9.1.1).

PIT Tag Relocations

The documentation of juvenile salmon migrating from the main channel and a tributary to off-channel habitats to overwinter is the only information gained from the detection of PIT-tagged resident fish and juvenile salmon. The standard scientific practice for PIT-tagging studies is to determine the portion of tagged fish moving from one location to another corrected by the ability to detect tags either as they approach or pass a stationary antennae or are detected by a hand held antenna (Bramblett et al. 2002). The study does not clearly state when fish were tagged and if detections only reflected fish tagged during winter or fish tagged at on any previous date. The text of the Technical Memorandum does not describe any analyses conducted to determine winter site fidelity or the timing of smolt outmigration, or if movements were associated with any other environmental variable, in particular, rising stage height during ice formation.

AEA detected tagged fish at stationary antennas (one at FA 104 and one at FA 128) and by scanning captured fish for PIT tags. The detection of tagged fish at the antenna documents a fish movement from the tagged location to the antenna site. Since there was only one antenna, it is not known whether the tagged fish approached or crossed the antenna. Therefore, it is not known if fish moved from the habitat on one side of the antenna to the habitat on the other side of the antenna. In addition, since the antenna was not operational over the entire sampling period and detection efficiency is unknown, it is unclear what the detection of a tagged fish indicates. For example, the report states that 676 Coho Salmon were tagged and 16 were detected at antennas. The report does not state when or where these fish were tagged or when or where these fish were detected. Therefore, even assuming tagged fish moved across an array, we don't know what portion of the fish tagged upstream of an array moved across the array, since most of the tagged fish are unaccounted for.

The Technical Memorandum states that Coho Salmon salmon showed little movement, as more than half of these 72 fish recaptured (~36 fish) were within the same Focus Area or macrohabitat where they were tagged. However, there is no information on where all of the fish were tagged or the probability of recapture. That is, if 90% of the fish were tagged within the Focus Area where they were recaptured, and 10 % were tagged outside the Focus Area, a recapture of half of the fish within the Focus Area would suggest that most tagged fish showed movement, since the probability of recapturing fish tagged outside the Focus Area was lower than the probability of capturing fish tagged within the Focus Area. If 300 of the ~600 tagged Coho Salmon salmon were tagged within the Focus Area and 36 were recaptured, what happened to the remaining 264 fish? If the probability of recapture was high, this would suggest that most fish emigrated from the Focus Area; however, if the probability of recapture is low this would suggest high site fidelity. Sampling effort also was not equal within and outside of Focus Areas. That is, as most if not all of the winter sampling occurred in a Focus Areas, it is highly unlikely that any fish tagged within a Focus Area would be detected outside of a Focus Area. Since the number of fish tagged within a Focus Area is not provided, the probability of recapture is unknown, and sampling only occurred in Focus Areas, then the fact that more than half of the recaptures occurring within the same Focus Area where they were tagged does not provide any useful information.

Knowledge of when fish were recaptured relative to tagging is also necessary to determine site fidelity. The only information provided within the TM is that fish were recaptured over 7 days after tagging. However, as sampling took place monthly, it is unclear what this means. Did sampling occur more often, than monthly within a Focus Area or did sampling within a Focus Area extend over a 7-day period and fish moved from a sampling site at one end of a Focus Area to the other end of the Focus Area during the sampling period? Fish tagged during November and recaptured in February during conditions of ice development would provide different information than a fish tagged in February and recaptured in March.

The study does not clearly state when fish were tagged or if the detections reported were only for fish tagged during winter. For example, AEA table 4.6-1 reports that 2 rainbow trout were tagged but that there were 12 detections at an array. This could mean that the two tagged rainbow trout were detected multiple times. However AEA section 5.2.7.2 states that the 12 fish detected were tagged between August 28 and September 21, so the report also tracks fish tagged during fall sampling. Therefore, it is not clear how many rainbow trout were tagged (2, 12, or some other number) and how many of these tagged fish were relocated. The report states that 9 rainbow trout were detected at the array that were tagged in Whiskers Creek or the classified side slough habitat within the mouth of Whiskers Creek. We don’t know the number of tagged rainbow trout within Whiskers Creek at the onset of the Winter Study or where within Whiskers Creek these fish were tagged. Therefore, we cannot identify the portion of rainbow trout in Whiskers Creek that migrated to the mainstem habitats to overwinter.

AEA Table 4.6-1 reports that 98 juvenile Chinook salmon were tagged, but it does not report when or where these fish were tagged. AEA Table 5.3.2.1 only reports on the tagging location of those fish detected. The report states that 20 of the 22 fish detected were found within the Focus Area where they were tagged suggesting that Chinook salmon remained within the Focus Area. However, if this 20 Chinook out of 98 than 1 in 5 remained within FA 104, or like rainbow trout, do these detected fish also include fish PIT-tagged during the August to September sampling and the total number of tagged fish are unknown. If another antenna had been present and sampling conducted further downstream, would 20 or more fish also have been relocated there and what would this mean regarding site fidelity. In addition, the report does not state when these fish were detected. Were they all during the November sampling? If so, were they still present in March? When was the fish tagged that migrated from Indian River (PRM 138) to Whiskers Creek (PRM 106) and when was it detected? Were fish movements associated with rising stage height during ice development in December (see Figure 1)? Since there is only a single antenna, we don’t know if tagged fish were moving into Whiskers Creek, out of Whiskers Creek or just approached the antenna and didn’t cross.

Emergence Timing

The TM identifies emergence timing based on the presence of target fish less than 40 mm occurring in monthly samples. These results reveal the presence of fry beginning as early as February, with a maximum number in April sampling. The TM does not provide results by sampling method or by sampling location. Electrofishing, which causes involuntary muscle contraction, can result in early emergence and result in erroneous results. Electrofishing results should be analyzed independently from and compared to fyke net results.

The presence of emergent salmon is an indication of spawning location. However, the study does not identify where emergent fish were captured. For example, the presence of emergent Chinook or Coho Salmon salmon within FA 128 or FA 138 could indicate spawning in off-channel habitats or early migration from known spawning streams. If Coho Salmon or Chinook fry are migrating during April, these newly emergent fish must be considered in fish passage barrier studies (Study 9.12). Alternatively, emergent Chinook and Coho Salmon salmon captured in Whiskers Creek would be an indication of spawning within this tributary, and support the need to extend the adult escapement study into the lower Middle River (see the Services RSP comments). If Chinook and Coho Salmon fry were captured in Whiskers Creek side channel or side sloughs, this would suggest that either spawning was occurring in these locations, or emergent fry were migrating to these locations and the presence of Chinook and Coho Salmon fry in off-channel habitats would need to be considered in any analyses of project effects and for the development of mitigation options. To evaluate project effects HSC curves would need to be developed for this life stage.

Growth Rates

Determining juvenile salmon growth rates among macrohabitats provides a metric that can be used to evaluate habitat quality and estimate survival among overwintering locations. Significantly higher positive Coho Salmon growth rates in upland sloughs could be used to indicate the relative importance of these macrohabitats. Conversely, negative growth could indicate poor overwintering habitat or abundance that exceeds carrying capacity. Growth rates could be used to evaluate the relative importance of habitat variables, for example water temperature and water velocity. Therefore, determining juvenile salmon growth rates provides a metric that is important for evaluating overwintering habitat. Growth rates are necessary to estimate the portion of juvenile salmon in each size class for Instream Flow analyses as current curves are size-class specific. These data can be used to evaluate habitat characteristics influenced by the proposed project operations.

The level of effort directed toward determining juvenile salmon growth rates was insufficient. The number of recaptured PIT-tagged salmon was insufficient to allow for statistical comparisons of growth among macrohabitats. The low number of fish makes it less likely that the growth rates measured are representative of the species or macrohabitat (2 to 3 for Chinook salmon, 7 to 28 for Coho Salmon salmon per AEA Figure 5.2.4-1). The low number of replicate macrohabitats sampled makes it unlikely that the growth rates measured are representative of the macrohabitats sampled (2 or 3 for 3 of the 5 macrohabitats). Differences in growth based on date of tagging reduce the probability of detecting differences among species or macrohabitats. Habitat characteristics were not measured at sampling locations; therefore, differences in growth among macrohabitats and as a function of habitat characteristics potentially influenced by project operations cannot be evaluated. Therefore, this study did not provide the information necessary to evaluate project effects or to develop effective mitigation options.

References

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9.7 Salmon Escapement

ISR Review and Study Modifications

Study Objectives

The objectives of the Upper River Fish Distribution and Abundance (FDA) Study identified in the Federal Energy Regulatory Commission (FERC) study plan determination (April 1, 2013) include:

1. Capture, radio-tag, and track adults of five species of Pacific Salmon in the Middle and Upper Susitna River in proportion to their abundance. Capture and tag Chinook Salmon, Coho Salmon, and Pink Salmon in the Lower Susitna River.
2. Characterize the migration behavior and spawning locations of radio-tagged fish in the Lower, Middle, and Upper Susitna River.
3. Characterize adult salmon migration behavior and timing within and above Devils Canyon.
4. If shown to be an effective sampling method, and where feasible, use sonar to aid in documenting salmon spawning locations in turbid water in 2013 and 2014.
5. Compare historical and current data on run timing, distribution, relative abundance and specific locations of spawning and holding salmon.
6. Generate counts of adult Chinook Salmon spawning in the Susitna River and its tributaries to estimate the proportions of fish with tags for populations in the watershed.
7. Collect tissue samples to support the Fish Genetic Baseline Study (Study 9.14).
8. Estimate the system-wide Chinook Salmon escapement to the entire Susitna River, the Coho Salmon escapement to the Susitna River above [the] its confluence with the Yentna River, and the distribution of Chinook, Coho Salmon, and Pink Salmon among tributaries of the Susitna River (upstream of the Yentna River confluence) in 2013 and 2014.

The National Marine Fisheries Service (NMFS) has evaluated the eight objectives to determine if the results in the Study Completion Report meet the objectives. Variances in the study were considered with respect to meeting the objectives. NMFS Study Modification requests are provided.

The Salmon Escapement Study was conducted during a period of very low Chinook Salmon abundance thus resulting estimates of Chinook Salmon escapement cannot and should not be considered as even approximately representative of the number of salmon moving upstream. The Salmon Escapement Study was effective at confirming Chinook Salmon use of some Upper River tributaries and that that Chinook Salmon spawn and rear far above the proposed dam site,

An important variance from the FERC-ordered study is that salmon were not captured and tagged at a location upstream from Portage Creek and below Devils Canyon. NMFS continues to recommend that this part of the study plan be fully implemented in order to adequately understand the number, timing, and characterization of Chinook Salmon that migrate into Devils Canyon and beyond the proposed dam site. Attempts were made to gather proxy information by installing a weir on Indian River, and sonar at the proposed dam site, but these efforts were not fully successful due to failure of the weir and incomplete sonar sampling across the channel and over the full Chinook Salmon adult spawning migration period upriver. This information is needed by NMFS to inform our fish passage prescription decision, and to develop Protection Modification and Enhancement Measures for the Project.

The Salmon Escapement Study confirmed that main-stem Susitna River macrohabitats (side channels, side sloughs, and upland sloughs) provide important spawning habitat and when escapement into the major glacial tributaries (Yentna, Chulitna, and Talkeetna Rivers) is excluded; provide a large portion of available spawning habitat within the Susitna River; and approximately 90% of Sockeye Salmon that enter the Middle River spawning in main-stem habitats.

NMFS Study Modifications

However, the study must be modified to adequately document main-stem salmon spawning locations by macrohabitat and provide information on physical habitat characteristics at spawning locations. Airplane and helicopter surveys that identified main-stem spawning locations must be followed with boat and foot surveys as described in the study plan so that main-stem spawning habitats can be adequately located and characterized; the spatial precision of aerial surveys is insufficiently accurate for gathering this necessary information. We need reliable, adequate information on the locations, types and numbers of main-stem off-channel habitats used for salmon spawning and to determine the macrohabitat type or types that are preferred spawning habitat for any particular salmon species. The adult escapement study, through ground and boat surveys, did not provide the necessary information on the characteristics of main-stem salmon spawning habitats at the macrohabitat and mesohabitat level. This information is necessary to determine if the two Middle River focus areas, where spawning surveys were conducted, are representative of the hundreds of side channels, sloughs, and tributary mouths in the Middle and Lower River that provide spawning habitat for Pacific salmon so that the ability to accurately extrapolate this information can be documented

The effect of variances from the FERC approved study plan and the inadequacy of the approved methods is that study objectives were not met. NMFS recommends that the FERC approved study methods be conducted as required and that the following study modifications be incorporated into the approved study plan in order for study objectives to be adequately met:

1-1 Spawning ground surveys to assess tagging representativeness;

2-1 Boat and foot surveys of Lower and Middle River spawning habitats;

4-1 Develop methods through the Technical Working Group to document spawning in turbid waters;

8-1 Conduct an additional year of tagging at capture locations in the lower Middle River and below Devils Canyon.

Review by Objective

Objective 1: *Capture, radio-tag, and track adult salmon*

Modification 1-1: NMFS recommends that spawning ground surveys be conducted to obtain size distribution for comparisons with tagged fish and identify any size tag sampling selection bias from fish wheel sampling and to obtain more accurate assessments of mark rates and escapement as provided for in the approved plan.

Over 9,000 adult salmon were captured and radio-tagged in the Susitna River Basin during the three-years of study. Total numbers of radio-tagged salmon by species are as follows: 3,880 large Chinook, 99 small Chinook, 2,291 Coho Salmon, 1,179 Chum Salmon, 1,427 Pink Salmon, and 509 Sockeye Salmon. Most yearly tagging goals by species were met. The majority of fish were captured with fish wheels. In some cases this catch was supplemented by gillnets. Pulse-coded radio-tags were deployed to captured fish that met the size requirements presented in the study plan. Tags were equipped with a mortality sensor, which activated after 24 hours of inactivity. Tagging assumptions of handling-induced changes in behavior, fish wheel effectiveness across time, and differences among stocks were statistically evaluated in the completion report.

The results of Objective 1 in the Study Completion Report raise several questions regarding the data collected and tagging assumptions. In order for the results to accurately characterize Pacific Salmon in the Susitna River and its tributaries, sampled fish must be representative of the population as a whole. Analysis of equal likelihood of capture and stock representation brings into question whether sampling was random and representative of the fish populations present.

Size-selectivity by capture method occurred in the Lower River and the Yentna River, as fishwheels preferentially captured smaller fish. Additionally, in 2013, too few Coho Salmon, Pink Salmon, Sockeye Salmon, and Chum Salmon were recaptured at weir sites to test for size-selectivity in the Middle River. As described in the study plan variances, no spaghetti tagging and subsequent spawning ground surveys were conducted for analysis of equal vulnerability of capture and tagging. Fixed-site sonar was used in place of the originally proposed methods of evaluation (a weir). Thus, this reduced the ability to meet the objective, due to the inability of sonar to differentiate species and to accurately collect length data. Video at weir sites was also implemented in an attempt to capture tag-rates and length data. However, video was not able to capture the presence of tag. We also note that during periods of high flows, observers had difficulty determining numbers and species of passing fish and inaccurate measurements of fish total length from video. No calibration of sonar or video length data took place to remedy this potential source of error. Additionally, the ARIS (Adaptive Resolution Imaging Sonar) unit at Site 1 intended to check for bias in fishwheel sampling was not operated from mid-July through August, and thus missed the peak of the Coho Salmon run.

Difficulties operating the Indian River weir further hindered fulfilling Objective 1. In 2013, weir counts at Indian River were stopped on August 20, the day after the observed peak of Coho Salmon, thus recaptured fish did not accurately represent the Coho Salmon run. In 2014, weir failure impaired the accuracy of mark rate and size-selectivity analysis in Middle and Upper River, as well as the estimated escapement values. Failure of weir prevented size-selectivity analysis and no fish were sampled for size at spawning grounds above Middle River tagging sites.

Objective 2: *Determine the migration behavior and spawning locations of the radio-tagged fish in the Lower, Middle, and Upper Susitna River*

Modification 2-1: For future requested tagging NMFS recommends that AEA conduct ground surveys of Lower and Middle River salmon spawning surveys to pinpoint spawning locations to macro- and mesohabitats and characterize quality of spawning habitat, including the physical and chemical habitat characteristics of those habitats. Surveys should be directed toward tag locations from previous years of study that were assigned main-stem spawning locations and surveys should be conducted at least weekly to document peak spawning activity. As stated in the Revised Study Plan (RSP) all tag detections (aerial surveys) were intended to direct ground and boat surveys to identify final spawning locations; however, this was not conducted and final spawning locations were not identified

AEA did not conduct ground surveys of potential salmon spawning locations as provided for in the FERC-ordered study plan. The study plan proposed that radio-tagged salmon would be monitored for migration, holding, and spawning times at specific locations, and to identify movement patterns. The RSP stated that when helicopter and fixed-wing surveys located adult salmon, boat and ground surveys would be conducted weekly to pinpoint fish locations within 10 meters. Instead, locations of tagged fish were monitored by fixed-station radio receivers at specific locations in the Lower, Middle, and Upper River; the number of receivers was fewer than proposed. Additionally, aerial surveys were conducted by helicopter and fixed-wing aircraft. Radio detections were used to classify fish as either holding or spawning, and fish were assigned a final destination in either main-stem or tributary locations. However, spatial resolution of these fish locations and classifications is not accurate enough to meet study objectives due to the precision limitations of radio-detection by aerial survey. Fish locations determined from aerial surveys without boat surveys to confirm cannot be used to accurately assign macrohabitat, mesohabitat, or other habitat characteristics to fish spawning locations. These data are important to inform Study 9.12 and Study 8.5 and must be accurate

The RSP for Study 9.7 states that results would be used to evaluate potential fish passage barriers. A large number of beaver dams were located in middle river side channel and off-channel habitats. Water depths within sloughs may also result in passage barriers. The timing and distribution of adult salmon at the mesohabitat scale is necessary to evaluate those beaver dams or water depths that were barriers to adult salmon migration. The information on spawning locations of adult salmon are necessary to identify locations where habitat characteristics can be measured to develop and validate habitat models for spawning salmon (Study 8.5).

Therefore, due to inadequate spawning surveys, Objective 2 has not been met. Although aerial surveys were conducted in accordance with the study plan, this survey method is not an adequate replacement for ground surveys. The finest spatial resolution of helicopter survey is 300 meters and of fixed-wing survey is 800 meters, which when conducted alone is not sufficient for identifying where fish spawn. Other complications of aerial surveys include high turbidity of glacial water, overhanging vegetation, and overall observer inefficiencies, limiting visual confirmation accuracy. The proposed intent of aerial survey was to direct ground surveys to track salmon to specific spawning locations and characterize spawning preference to the macrohabitat level. Several "potential" spawning locations were determined per species; however, most were unable to confirm spawning activity. Of the 13 "potential" Middle River Chinook Salmon spawning sites, eight were not surveyed and only one was confirmed. Of the 17 "potential" Middle River Coho Salmon spawning sites, none were confirmed (see Table D2 through D4 in the Study Completion Report). In the few instances where spawning was confirmed, no habitat characteristics or physical chemistry measures were recorded or provided in the study report. No surveys are reported for the Lower River. A sufficient sample size of confirmed spawning destinations is necessary to characterize spawning habitat associations, which can then be used to determine project effects on these spawning habitats. This information is needed to determine the effects of project operations on fish spawning and the information gathered and reported so far is inadequate to meet that need.

A significant number of Pacific Salmon spawn within the glacial main-stem habitats. A minimum of 6 – 33% of Middle River Chum Salmon, Pink Salmon, Coho Salmon, and Sockeye Salmon spawned in main-stem habitats. However, when the major glacial tributaries (Yentna, Chulitna, and Talkeetna Rivers) are excluded, these percentages increase from 19% to 90%. It is not known if tributary mouths, side sloughs, side channels, or upland sloughs are selected for spawning or if species are segregating by selected macrohabitats for spawning. The Instream Flow Study (study 8.5) is beginning to develop models to predict chum and sockeye spawning habitat based on water depth, velocity, and substrate. Based on these models, there are multiple locations throughout the Middle and Lower River that should support chum and sockeye spawning, but do not.

The information gained from conducting the boat and foot surveys of spawning habitat is important and necessary for the evaluation of project effects and we recommend that this study task should be conducted as provided for in the approved study plan. The related Instream Flow Study has not developed models for Coho Salmon spawning even though 6% of Coho Salmon tagged in the Middle River were assigned main-stem spawning locations. In order to accurately evaluate project effects, spawning habitat models need to be applied only to those areas that actually support spawning for that species. Extrapolation of results to Middle and Lower River outside of areas where hydraulic modelling is occurring requires an understanding of the distribution of similar Middle and Lower River spawning habitats (which most likely will be based on macrohabitat or mesohabitat classification). Project effects are also likely to be worse in more lateral upland and side slough habitats, further supporting the need to understand the distribution of main-stem salmon spawning by macrohabitat classification. Even if results are not extrapolated outside of focus areas, it must be determined whether the small numbers of spawning habitats in focus areas are truly representative of the larger river.

Objective 3: *Characterize adult salmon migration behavior and timing within and above Devils Canyon*

Under Objective 8 NMFS recommends additional tagging above Indian River but below Devils Canyon, as required in the study plan, to adequately quantify the number, size, and distribution of Chinook Salmon migrating into the Upper River. This data will provide information that is necessary NMFS fish passage prescription decision.

Objective 4: *Use available technology to document salmon spawning locations in turbid water*

Modification 4-1: NMFS recommends that AEA work with the Technical Working Groups (TWGs) to develop and propose additional methods to FERC to use to locate and document Pacific Salmon spawning in turbid waters at sites classified as main-stem spawning locations in previous tagging studies. Suggested methods include:

- Limited gill netting;
- Late September or early October redd surveys during clearwater conditions; and
- Pumping or excavating potential redd sites.

A significant portion of Susitna River salmon that were radio-tagged were assigned main-stem spawning locations. Since ground surveys were not conducted as provided for in the RSP, it is not known if salmon or salmon species showed a preference for main channels, side channels, side sloughs, upland sloughs, or tributary mouths. Additionally, it is also not clear the number of salmon that spawned in turbid or clear water. The distribution of salmon spawning in turbid or clear water is necessary to understand the current environment, to develop spawning habitat models, and to evaluate post-project changes in salmon spawning distribution. DIDSON sonar was proposed as the available technology to document salmon spawning in turbid water. Sonar units were attached to and operated by boat. The RSP stated that any potential salmon spawning location would be surveyed by operating the sonar for up to 30 minutes when spawning activity was suspected.

Numerous issues arose with the use of sonar technology; including the failure to document salmon spawning locations in turbid water. Additionally, accessibility of boat-mounted sonar units was limited in shallow water and shoreline habitat. Researchers were unable to distinguish between fish species and unable to identify redds. As a variance from the study plan, project staff determined that only Chinook Salmon could be distinguished from other species, based solely on their relatively larger length. Of the potential spawning locations determined by sonar, very few were confirmed. Our recommendation to develop methods through the TWG to identify salmon spawning in turbid waters will improve these study limitations.

Objective 5: *Compare historical and current data on run timing, distribution, relative abundance, and specific locations of spawning and holding salmon*

NMFS is not recommending any study modifications under this objective. However, we do not agree with the presentation or interpretation of data collection efforts. Objective 5 sought to compare research conducted in the 1980s to the results of the current studies, in order to determine if shifts have occurred in run timing, distribution, spawning, and abundance since the last extensive research was conducted in the Susitna River drainage. Descriptive statistical analyses were conducted between the 1980s studies and the current studies, primarily concerning run timing and destination of tagged fish. Enough data was collected in both the 1980s and currently to conclude that neither the timing nor the distribution of salmon has changed significantly in the last 30 years.

A large amount of salmon spawning habitat is provided for by the main-stem of the Susitna River and its side channels, sloughs, and tributary mouths. For example, approximately 1/3 of the Coho Salmon that spawned in the Middle River, but were tagged in the Lower River, spawned in main-stem habitats (0.6/2.6). More Coho Salmon spawned in the Middle River main-stem (up to 16% per the SIR) than in Portage Creek. The portion of Sockeye Salmon spawning in main-stem Middle River habitats is 44% for fish tagged in the Middle River. Results show that >25% of the sockeye tagged in the Lower River main-stem, that do not enter the Yentna, are selecting main-stem spawning habitats. However, the SCR Figure D9 only shows tagged sockeye destined for the Yentna River.

To document lower middle river Coho Salmon spawning locations, additional tagging of Coho Salmon at Talkeetna Station should be conducted along with foot surveys to verify spawning locations. AEA needs to discuss the differences between Middle River tributary Coho Salmon spawning between current studies compared with studies conducted in the 1980s. In current studies, Coho Salmon tagged in the Middle River at Curry spawned in Upper River tributaries (Indian River and Portage Creek). In the 1980s, fish were tagged at Talkeetna Station in the lower Middle River, and the majority of spawning was documented as occurring in Whiskers Creek, Chase Creek, and Gash Creek (far downstream of the current tagging site at Curry). These lower Middle River tributaries likely continue to be important for Coho Salmon spawning; however, their use is underestimated due to the upstream tagging location at Curry. The SCR provides a number of tables to document roaming: fish that were tagged at Curry but ultimately spawned downstream as support of tagging fish at Curry instead of Talkeetna Station (tagging site used in the 1980s at PRM ~106). However, AEA did not attempt to determine the distribution of salmon into the Yentna River drainage or the Deshka River from tagging locations 22 miles upstream. Thus, current studies are not precise enough to confirm spawning areas in the lower middle river.

Objective 6: *Generate counts of adult Chinook salmon spawning in the Susitna River and its tributaries*

NMFS does not recommend any study modifications directed toward achieving this objective. However, we do not agree that the applied methods provide an accurate assessment of salmon escapement into tributaries and these estimates should not be relied on for assessment of current conditions or used to predict the effects of project operations on spawning habitat.

Generating counts of adult Chinook Salmon was proposed by determining mark rates at the Indian River weir. However, multiple variances from the proposed study plan mean that Objective 6 has not been met. Multiple technical failures, including the loss of the Indian River weir and the inaccuracies associated with aerial survey result in estimates that cannot be considered accurate without further explanation as to AUC methodology accounting for potential error used in escapement methods.

The primary concern with the escapement data for this objective is the AUC method issues. Originally, it was proposed that ground surveys would be used to test for equal vulnerability of capture. However, ground spawning surveys were replaced with weir and video at Indian River. Loss of Indian River weir prevented recapture data from being collected in this manner and also resulted in no length-frequency data collection. Aerial survey for radio-tag detection quickly replaced this loss; however, both a low and wide range of observer efficiency was calculated (35-80%). In order for the AUC method to be considered accurate, observer efficiency (error) must be accounted for (i.e. ground stream survey). No explanation is provided as to how this was accomplished. Poorly calculated observer efficiency could greatly bias escapement estimates. Further discrepancies exist in the difference between calculating "counts" of spawning salmon versus "escapement estimates," which in the study completion report it is clearly provided as an estimate as opposed to an actual count of the number of salmon observed spawning. AEA should make clear exactly what fish "counts" are and how they will be used; this has been a longstanding, unresolved issue since the study was first proposed.

Objective 7: *Collect tissue samples to support the Fish Genetics Study*

Objective 7 was carried out by collecting tissue samples from captured adult salmon. Because this objective was intended to support the Fish Genetics Study and analyses completed by the Alaska Department of Fish and Game, the results are provided in a different section of the completion report. If a weir is constructed in the Oshetna River and Kosina Creek to enumerate Chinook Salmon escapement and allow for recapture of tagged fish, the opportunity exists for additional samples to be collected for the genetics study.

Objective 8: *Estimate the system-wide Chinook Salmon and Coho Salmon escapement to the Susitna River above the Yentna River and the distribution of those fish among tributaries of the Susitna River*

Modification 8-1: NMFS recommends that an additional year of study be conducted with fish capture and tagging occurring in the Lower Middle River near the historic Talkeetna Station and at a second location upstream from Indian River but below Devils Canyon. We recommend an a priori statistical analysis be conducted to determine the number of additional tagged fish required to yield sufficient identification of spawning habitat locations in the lower Middle River site (Coho Salmon, Sockeye Salmon, Chum Salmon and Chinook Salmon). We also recommend that all Chinook Salmon be tagged at the site below Devils Canyon. Tracking tagged fish should be conducted following the methods specified in the FERC-ordered study plan. NMFS recommends that weirs be installed and maintained on main-stem Sustina at or upstream of the head of the proposed reservoir, at Kosina Creek and the Oshetna Rivers to recapture tagged fish and for additional genetic sampling.

The study results in the SCR document much lower Coho Salmon escapement and main-stem Chum Salmon and Sockeye Salmon spawning in the lower Middle River compared to studies conducted in the 1980s. The distribution of fish roaming downstream from the tagging locations is not the accepted scientific practice to document the relative distribution of salmon among spawning locations. We note that two of lower Middle River tributaries are within focus areas and one of the tributaries contains potential migration barriers.

As stated in the SCR, in the 1980s, Coho Salmon escapement was highest in Gash Creek, Whiskers Creek, and Chase Creek. Other important lower Middle River tributaries included McKenzie Creek, Lane Creek, and Little Portage Creek. Results from the current study identify Indian and Portage Creek as the major tributaries of Coho Salmon spawning. Either there has been a major shift in tributary habitat use or migration barriers (e.g. perched culvert in Gash Creek), or the probability of tagged Coho Salmon entering these tributaries was low because the capture and tagging site was 20 miles upstream. Tagged Coho Salmon that moved upstream from the Curry tagging location, had a limited number of spawning tributaries. However, a fish that moved downstream could have selected any tributary through the entire drainage as a potential spawning location. For example some tagged Coho Salmon migrated into the Talkeetna and Chulitna Rivers. Therefore, the percent of tagged fish moving into Whiskers Creek is not comparable to the percent of tagged fish that moved into the Indian River. It is not the standard scientific practice to locate a tagging site this far upstream of potential spawning locations. AEA did not locate the Lower River capture and tagging site at Willow Creek to document escapement into the Yentna or Deshka Rivers.

Results for the adult escapement study, as described in the RSP, were to provide information to the fish passage barriers study. There is a potential migration barrier due to a perched culvert in Gash Creek (FA 113). However, since tagging was not conducted in the lower Middle River, we do not know if Coho Salmon escapement is currently lower due to this barrier, the number and length of fish that passed this barrier, or the timing of fish passage relative to tributary flows.

AEA made the decision not to install the Devils Canyon fish wheel as provided for in the approved RSP. This study modification was made without formal review as required by 18 C.F.R. Sec. 5.13, which sets forth the process for study plan approval. In part AEA stated that escapement above Devils Canyon could be estimated from recaptures at the Indian River weir. However, this was not accomplished due to the unfortunate loss of the weir. In addition, there are a number of limitations if evaluating passage conditions through Devils Canyon as described in the SCR. The number of Chinook Salmon migrating to Upper River spawning locations and conditions that provide for passage through Devils Canyon are important information needed NMFS fishway prescription decision and to determine the instream flow that would be necessary to allow Chinook Salmon passage through Devils Canyon to collection facilities or other upstream fish passage facilities.

The variance that eliminated the use of a weir in the Middle Fork of the Chulitna requires us to assume that results from the Deshka River and Montana Creek weirs sufficiently represent all mark-recapture rates for the entire lower Middle River. This potentially affects the accuracy of escapement estimates. The installation of a weir on the main-stem Susitna River above the head of the proposed reservoir, at Kosina Creek, and at the Oshetna River, during July and August would allow for the recapture of tagged Chinook Salmon and calculation of more accurate escapement estimates into the upper river.

9.8 River Productivity

ISR Review and Study Modifications

The River Productivity Study is intended to provide information on the effects of hydropower operations on the productivity of rivers in general, and collect sufficient baseline data on which to base estimates of productivity in the different habitat types in the Susitna River in particular. Understanding how differences in food availability, food quality, temperature, and velocity affect juvenile salmon growth among macrohabitats will provide necessary information for evaluation of the current environment and probable project effects. This information will be used to assess effects of the Project on the river's productivity. This information is necessary for National Marine Fisheries Service (NMFS) to develop measures that if implemented would protect, mitigate or enhance affected resources.

This study was not implemented in accordance with the approved study plan, limiting its value for providing information necessary for NMFS in assessing project impacts. The objectives of the River Productivity study were not met through implementation of the "first" study year's field methods (2013 and 2014). Our review identified inconsistencies between the study plan (RSP) and the implementation plan (3/1/2013), including inconsistent sampling methods or sampling effort among sampling locations which compromise the data and obfuscate analysis. We have provided study modification requests which are intended to improve study methods, implementation and analysis so that study results can meet objectives and inform other inter-related studies. Integration of this study with interrelated studies will be best accomplished by a new study for Model Integration. A New Study request for Model Integration is included as an enclosure.

The River Productivity study was not planned to be conducted in all focus areas, thus sampling locations did not need to be restricted to focus areas. The study was conducted only in focus areas. The result is that sampling does not adequately replicate macrohabitats. Important habitats were not sampled, fish sample sizes were inadequate to support the bioenergetics study, and the stable isotope study was not conduced at salmon spawning and juvenile salmon rearing locations. The focus area concept was developed for the Instream Flow Study to study areas that represent each geomorphic reach. Focus areas were developed as sites where intensive data are to be collected and 2D hydraulic and geomorphic modelling would be conducted. The River Productivity study is not providing detailed information for any of the focus areas, is not representing all geomorphic reaches, and has no sampling sites within those focus areas most important for adult and juvenile salmon (FA138 and FA128).

NMFS requests that the second year of study the River Productivity study be conducted in five or six replicates of each macrohabitat type within the Middle River regardless of whether they occur within or outside of a focus area. Emphasis should only be placed on site selection within focus areas to the extent that this fits with the primary objective of selecting optimal sites and providing adequate replication of macrohabitats.

The bioenergetics modeling is a critical study as determining differences and factors that limit juvenile salmon growth among macrohabitats will provide additional information on the current environment not provided for through the Fish Distribution and Abundance (FDA) studies and Instream Flow studies. Study results will provide information necessary to evaluate project effects, beyond the habitat models predicting salmon presence or absence due to differences in water velocity and depth. However, the study failed to meet study objectives because: (1) site selection did not replicate side slough and upland slough habitats, (2) juvenile salmon were not tagged as provided for in the plan and sample sizes were too small to provide accurate or representative measures of growth, (3) sample sizes of stomach contents were too small to accurately describe juvenile salmon diets, and (4) water temperature data were not representative of site conditions.

Study Objectives

The nine objectives of the River Productivity Study identified in the Federal Energy Regulatory Commission (FERC) study plan determination (April 1, 2013) are:

1. Synthesize existing literature on the impacts of hydropower development and operations (including temperature and turbidity) on benthic macroinvertebrate and algal communities.
2. Characterize the pre-Project benthic macroinvertebrate and algal communities with regard to species composition and abundance in the Middle and Upper Susitna River.
3. Estimate drift of benthic macroinvertebrates in selected habitats within the Middle and Lower Susitna River to assess food availability to juvenile and resident fishes.
4. Conduct a feasibility study in 2013 to evaluate the suitability of using reference sites on the Talkeetna River to monitor long-term Project-related change in benthic productivity.
5. Conduct a trophic analysis to describe the food web relationships within the current riverine community within the Middle and Lower Susitna River.
6. Develop habitat suitability criteria for Susitna benthic macroinvertebrate and algal habitats to predict potential change in these habitats downstream of the proposed dam site.
7. Characterize the invertebrate compositions in the diets of representative fish species in relationship to their source (benthic or drift component).
8. Characterize organic matter resources (e.g., available for macroinvertebrate consumers) including coarse particulate organic matter, fine particulate organic matter, and suspended organic matter in the Middle and Lower Susitna River.
9. Estimate benthic macroinvertebrate colonization rates in the Middle Susitna Segment under pre-Project baseline conditions to assist in evaluating future post-Project changes to productivity in the Middle Susitna River.

NMFS Study Modifications

Explained in further detail below but summarized here, NMFS requests the following study modifications to improve the methodology and increase the likelihood of meeting the approved study's goals and objectives:

1-1 Provide a description of the key words and databases used for literature searches so the completeness of this review can be ascertained.

2-1(a-c) Repeat benthic macroinvertebrate, benthic organic matter, and periphytic algal sampling at all tributary mouth sampling locations, or at a minimum of 6 in total, to complete the study the approved study plan. Complete periphytic algal sampling at upland slough sampling locations (minimum of five) to complete the study per the approved study plan.

a. Sample at a minimum of five replicate upland slough habitats per the study plan. Do not use data from the sampling sites referred to as upland slough near Montana Creek. Instead, select and sample actual upland slough habitat.
b. Co-locate upland slough sites selected or the River Productivity study be co-with upland sloughs sampled for the Fish Distribution and Abundance (FDA) study.
c. Sample additional upland sloughs in the Middle River below Devils Canyon.

2-2 Select side slough sampling units and sampling locations per the approved study plan.

2-3 Select side channel sample units that are representative of the side channel macrohabitat type, and select and sample locations within the side channel sampling units which are distributed throughout the 500 m sampling unit, per the approved study plan.

2-4 Select main channel sampling units within each focus area which are representative of this macrohabitat type, a minimum of 6 units per focus area. The sampling locations within these main channel sampling units must be distributed throughout the 500 m sampling unit as provided for in the approved study plan

2-5 Collect macroinvertebrate samples from locations and depths that are within the active channel under most flow conditions and in main-stem and side channels that are representative of the dominant mesohabitat .

2-6 Collect invertebrate and algal samples from sites dominated by fine substrates so that the samples are representative of the dominant habitat per the approved study plan.

2-7 Collect algal samples from multiple depths (0-1, 1-2, 2-3 feet) within each macrohabitat proportional to the depths present and such that all sites are inundated for 30 day prior to sampling, following the study plan.

2-8 Collect benthic macroinvertebrate and algal samples during the spring, summer, and fall sampling periods for a minimum of two years as described in the approved study plan.

2-9 Repeat the invertebrate emergence study in a subsequent year to obtain adequate replication among all macrohabitats.

3-1 Measure invertebrate drift upstream and downstream from tributary mouths during the second year of sampling as provided for in the approved study.

3-2 Conduct drift sampling every 4 hours in one or more of each representative macrohabitat to determine diel variation in drift during each sampling event.

3-3 Repeat tows in slow water habitats using a mesh sized for zooplankton collection in order to estimate the contribution of zooplankton as a food resource in these habitats.

4-1 Conduct sufficient reference sampling in the Talkeetna River to provide replicate measures of all five of the major macrohabitats.

5- Modify the Growth Rate and Growth Rate Potential Modelling study as detailed in modifications 5-1 through 5-4 starting on page 33.

7-1 Collect and analyze diets from a minimum of 8 fish with food in their stomachs for each fish species and life stage, as required in the study plan (Objective 7).

G-1 (Global) Expand the geographic scope of the River Productivity Study to the Lower River.

<u>Summary of NMFS Previous Outstanding Comments</u>

Following is a summary which recaps previous issues NMFS raised that are still unaddressed in the study report despite them being raised and recommended during pre-licensing activities to date. These are presented here for FERC's use in making the updated study determination and to augment the record for this study.

NMFS' comments on the Revised Study Plan (RSP) (March 18, 2013) were not taken into account in modifications made to the River Productivity Study Plan and NMFS was not consulted regarding these modifications.

We also raised concerns that macroinvertebrate sampling using a Hess sampler would result in samples collected at shallow depths in previously dewatered sample sites. To prevent these sampling problems we recommended different sampling methods. Our concerns were confirmed in 2013 sampling about 50% of the invertebrate sampling locations had been dewatered within 30 days prior to sample collection.

We recommended that algal samples be collected at multiple different depths to ensure evaluation the effects of light on primary production. FERC's study determination (April 1, 2013) incorporated this recommendation. However, algal samples were collected in front of the Hess sampler as originally proposed by AEA and all of the samples were collected in water depths less than 1.5 feet.

We raised the valid concern that the Hess sampler would result in all samples being collected from riffles, even though this mesohabitat is rare within the Middle River. All samples *were* collected from riffles, which represents less than 1% of available main channel habitats.

We recommended sampling algae in off-channel habitats from the dominant substrate, however, per the Initial Study Report (ISR), samples were collected from cobbles even in habitats where they were rare.

We recommended that drift samples be collected upstream and downstream from tributary mouths. This recommendation was supported by FERC but was not implemented.

We recommended that growth rates within macrohabitats be obtained from tagged fish to ensure that rearing occurred in that location. This recommendation was supported by FERC, but was not implemented by AEA.

We commented that the RSP and IP (March 18, 2013) did not provide locations for stable isotope sample collection. FERC required consultation with NMFS to select sites for stable isotope sampling, however, this consultation did not occur.

We requested, and FERC required, testing for relationships between measures of benthic and drifting invertebrates and rearing juvenile salmon. However, there were only two focus areas where this hypothesis could be tested, and fish and macroinvertebrate sampling occurred in different locations.

Review by Objective

Objective 1: *Synthesize literature on the impacts of hydropower development and operations (including temperature and turbidity) on benthic macroinvertebrates and algal communities.*

Modification 1-1: Provide a description of the key words and data bases used for literature searches in order for review participants and FERC to determine the completeness of this review.

AEA produced a literature review which attempted to thoroughly synthesize three topics: macroinvertebrate and algal community information in Alaska, general influences of environmental variables on benthic communities, and potential effects of hydropower operations. The review included 500 reports and papers. This synthesis provided a good but incomplete summary of relevant literature. AEA's review was missing 27 of the 53 published papers that NMFS identified as important when conducting a similar limited search. Many of these citations were cited in previous NMFS comments and thus readily available to AEA. While the synthesis presented in the ISR is useful and informative, it is not complete. Many important reports and published papers that would make the synthesis more complete are not included. No details were provided on the methodology of the literature search. Therefore, NMFS is requesting that prior to the second year of study, AEA provide a list of the key words and data bases and any other methods used to develop the literature review., and, that AEA improve the review with more recent publications. One area of improvement needed is literature which addresses changes to river productivity due to climate change, which is and will continue to affect the Susitna River (see NMFS Study Modification Request for 7.7, Glacier and Hydrology Changes for a complete discussion of this important topic).

Objective 2: *Characterize the pre-Project benthic macroinvertebrate and algal communities with regard to species composition and abundance in the Middle and Upper Susitna River*

Modification 2-1: Repeat benthic macroinvertebrate, benthic organic matter, and periphytic algal sampling at all tributary mouth sampling locations to complete the study per the study plan using appropriate sampling methods for water depths and velocities. Implement accepted macroinvertebrate and algal sampling scientific practices. Sample benthic macroinvertebrates, benthic organic matter, and periphytic algae from six or more additional tributary mouths in the Middle River below Devils Canyon.

The number of tributary mouths sampled was insufficient to evaluate the value of these macrohabitats for rearing juvenile salmon and resident fish species. Samples are not representative of this habitat type because the entire tributary mouths were not sampled and all samples were collected from approximately the same site. Therefore, samples will not yield adequate estimates that are representative of this habitat type or the range of water depths, flows, and substrates present in tributary mouths. Only two tributary mouths sampled were below Devils Canyon which overlapped with the distribution of juvenile salmon (Indian River and Montana Creek) and only one of these was in the Middle River. This is insufficient replication to use ANOVA to test for significant differences among macrohabitat types, as proposed, or to test for relationships between fish distribution and abundance and macroinvertebrate density as recommended by FERC for IFS Study 8.5 (see NMFS comments on AEA's Microhabitat Variables Tech Memo).

At all tributary mouth sampling units, sampling locations for the five replicate samples were collected in tributary deltas and none of the samples were collected with the portion of the main channel influenced by tributary flow (Figure 1 and 2). Tributary mouths are characterized by AEA as clearwater areas where tributaries flow into the main-stem. The macrohabitats can be further subdivided into tributary deltas and clearwater[1] plumes. Sampling units for the FDA Study 9.6 were further defined by FERC to include the tributary delta and 200 m downstream in the main-stem channel. Physical and water quality characteristics differences between the tributary delta (which is characterized by unstable substrate and shallow water depths), and the tributary-influenced main-stem (characterized by shallower slopes and greater depths). Juvenile salmon and resident fish may be more abundant within the main-stem influenced portion of this macrohabitat due to greater water depths, cover, and possible higher productivity than other main-stem sites. Organic matter may deposit in these portions of the macrohabitat, and algal abundance may be higher due to reduced scour and more stable substrate. Therefore the study must accurately document conditions within these macrohabitats.

[1] "Clearwater" has not been defined, but is assumed to refer to an area of reduced main-stem turbidity due to tributary discharge.

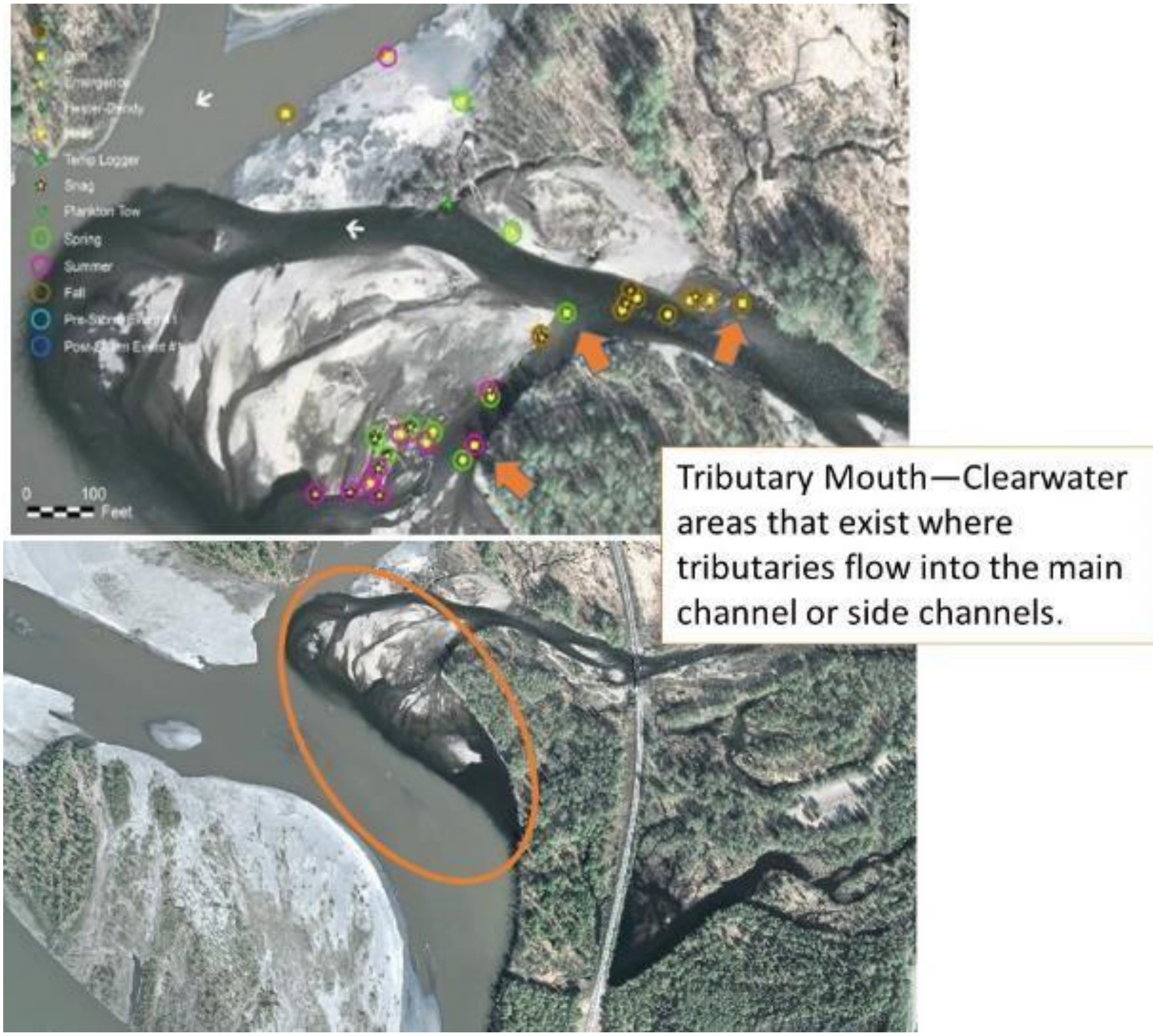

Figure 1. Benthic invertebrate, algal, and drift sampling locations in Montana Creek (upper) and aerial photograph of the Montana Creek with tributary mouth habitat outlined. Arrows point out drift sampling locations. Sampling locations are not representative of tributary mouth habitat since all samples were collected in the tributary delta and no samples were collected in the clearwater area where the tributary flows into the main channel. Drift samples (yellow squares and arrows) were not collected in the main-stem below the tributary mouth as required by FERC.

Figure 2. Benthic invertebrate, algal, and drift sampling location in Indian River (upper) and aerial photograph of the Indian River with tributary mouth habitat outlined. Arrows point out drift sampling locations. All samples were collected in the shallow high velocity tributary and are not representative of tributary mouth habitat. Drift samples were not collected in the clearwater area that flows into the main chanel as provided for in the aproved plan. This is the only Middle River tributary mouth sampled that overlaps with the distribution of most juvenile anadromous salmon in the Middle River.

Replicate samples within a sampling unit were all collected within very close proximity to each other (< 10m apart), rather than from distributed locations as required in the study plan. The Final River Productivity Implementation Plan (IP) states that benthic sample will be collected from five “suitable locations, spacing them as equidistantly as possible, to be representative of the site.” Therefore, for a 200 m tributary mouth, sampling locations should have been selected about every 40 m. The IP further states, “If five unique and separate locations are not available, it will be necessary to collect more than one sample within the same location. If this is the case, space the sample locations out as far as possible. For example, if conditions require two samples in one riffle area, sample at the downstream end and then the upstream end. As a general rule, samples should not be taken within 10 m of each other. Selected locations at each site should be sampled in a downstream-to-upstream direction.” It is clear from the sampling locations presented in Figures 1 through 3 [the distribution of sampling sites in AEA’s Study Implementation Report (SIR) largely expand on GPS points in the ISR figures], that this methodology was not implemented per the study plan. If samples were collected every 10 m then sampling would be distributed at a minimum over 40 m; however, samples tributary mouth samples were all collected within the tributary delta and within close proximity to each other. Collecting all samples from the same location will reduce the variability in sampled depths, velocities, and substrates within a macrohabitat, and impair the ability to develop accurate habitat suitability criteria curves or models for macroinvertebrates (Objective 6).

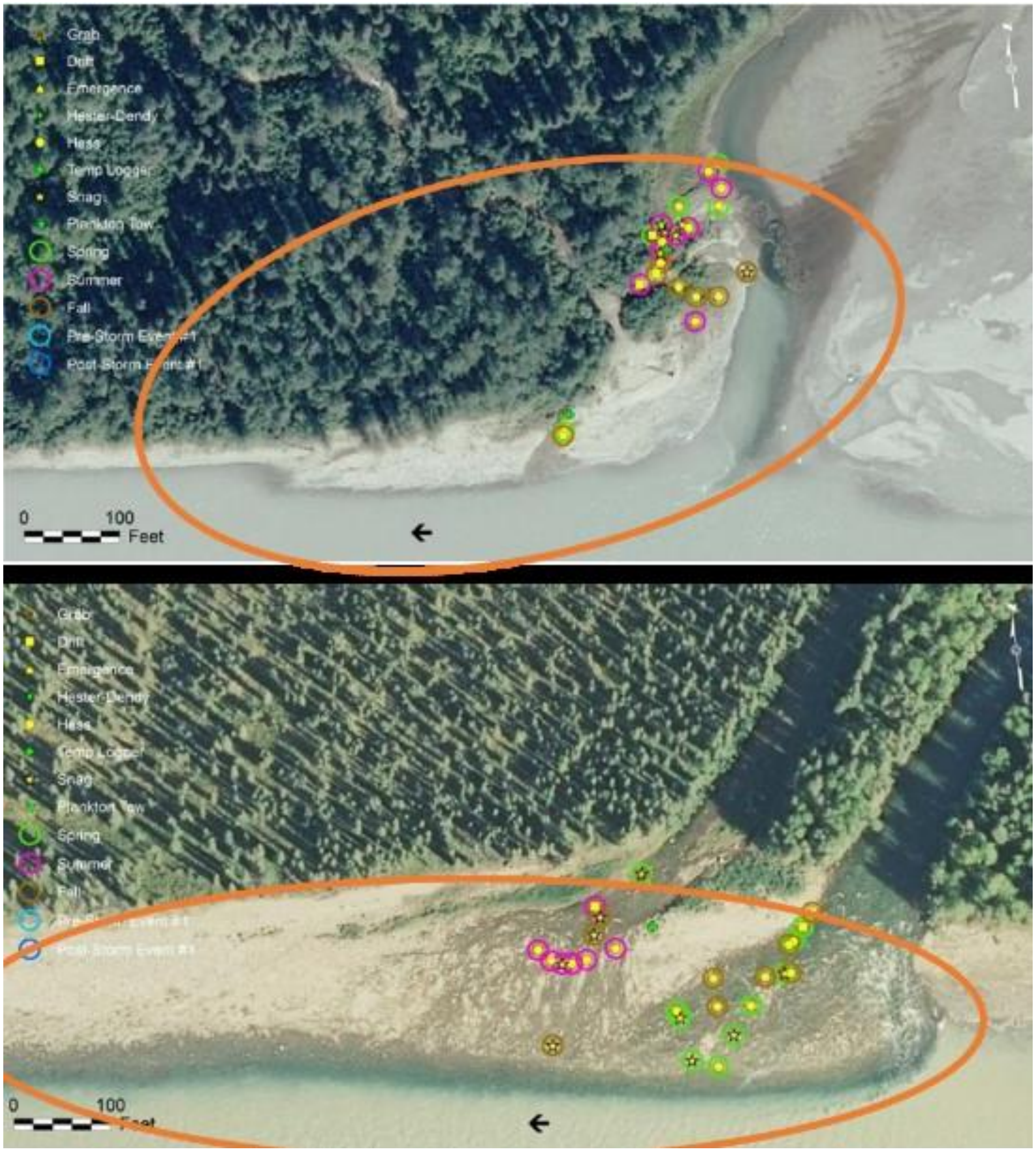

Figure 3. Benthic invertebrate, algal, and drift sampling location in FA 171 and FA 184. All samples were collected in the shallow high velocity tributary and are not representative of tributary mouth habitat. Drift samples were not collected in the main channel above and below tributary mouths as recommended by FERC. Sampling locations were likely dewatered 30 days prior to spring sample collection. All replicates sampled are collected from the same immediate location.

NMFS RSP comments (March 18, 2013) recommended a minimum of six replicate sampling units for each macrohabitat type. The FERC study determination (April 1, 2013) estimated, based on habitat classification in the RSP and IP that the study would provide approximately five replicates of each macrohabitat type. It is necessary for our evaluation of the effects of proposed project to determine if tributary mouth habitat is important for summer rearing and overwintering of juvenile salmon, and if so, whether this is due to differences in food availability. The FDA study was designed to measure the relative abundance of juvenile salmon in tributary mouth habitat and the River Productivity study was designed measure the density of benthic invertebrates and drift, and the Instream Flow study was to evaluate the importance of invertebrates for modelling fish abundance. However, the productivity study did not collect benthic or drift samples downstream from tributary discharge points. Only two tributary mouths were sampled downstream from Devils Canyon where juvenile salmon are more abundant (Indian River and Montana Creek), and FDA sampling was only conducted at Indian River (see AEA ISR 9.6 Appendix A). Therefore there is only one tributary mouth location were both fish and invertebrates were supposed to be sampled and invertebrates were not collected at representative locations within the clearwater plume. Because of these study implementation variances, the study objectives cannot be met unless modified as requested here.

Productivity sampling in all Focus Areas will provide necessary replicate measures of tributary mouth habitat downstream from Devils Canyon: Portage Creek, an important Chinook and Coho spawning tributary, is located in FA 151; an unnamed small tributary flows into FA 144; Indian River is in FA 141; Gold Creek is just upstream from FA 138, Skull Creek is in FA 128; a small unnamed tributary flows into FA 115; Gash Creek is in FA 114, and Whiskers Creek (if classified correctly) is in FA 104. Sampling within all Focus Areas would meet the intent of the development of these areas where detailed information was to be provided and provide adequate replication of Middle River tributary mouths.

Modification 2-1 (a-c): Repeat sampling of benthic macroinvertebrates, macroinvertebrate drift, benthic organic matter, and periphytic algae at upland slough sampling locations per the study plan, using appropriate sampling methods for water depths and velocities, and implement accepted macroinvertebrate and algal sampling scientific practices:

a. Sample at a minimum of five replicate upland slough habitats, per the study plan. Do not use data from the sampling sites referred to as upland slough near Montana Creek. Instead, select and sample actual upland slough habitat.
b. Co-locate upland slough sites selected or the River Productivity study be co-located with upland sloughs sampled for the FDA study.
c. Sample additional upland sloughs in the Middle River below Devils Canyon.

Only two upland sloughs were sampled for River Productivity for the entire Susitna River and sampling within these sampling units did not follow the approved plan. AEA reports that samples were collected from an upland slough near Montana Creek; however, the site is *not* an upland slough, but an old Montana Creek distributary channel (Figure 4). Water was diverted from this channel in the 1960’s during construction of the Parks Highway. The channel backs up behind a railroad culvert to give the appearance of a slough but this site does not function ecologically as an upland slough and is not representative of this habitat. Therefore results from this site cannot be used to meet the objective of this study. An alternate upland slough site is available just upstream of Montana Creek and should be sampled during subsequent study years (Figure 5).

Figure 4. Benthic invertebrate, algal, and drift sampling location in Montana Creek site classified as an upland slough (top photograph); however, aerial photograph of this location (oval in middle photograph) shows that this is a distributary of Montana Creek and not a Susitna River overflow channel. Data from this site should be discarded. This is one of only three sites selected to represent upland sloughs. Lower photograph shows true upland slough habitat near Montana Creek that NMFS requests be sampled for this study.

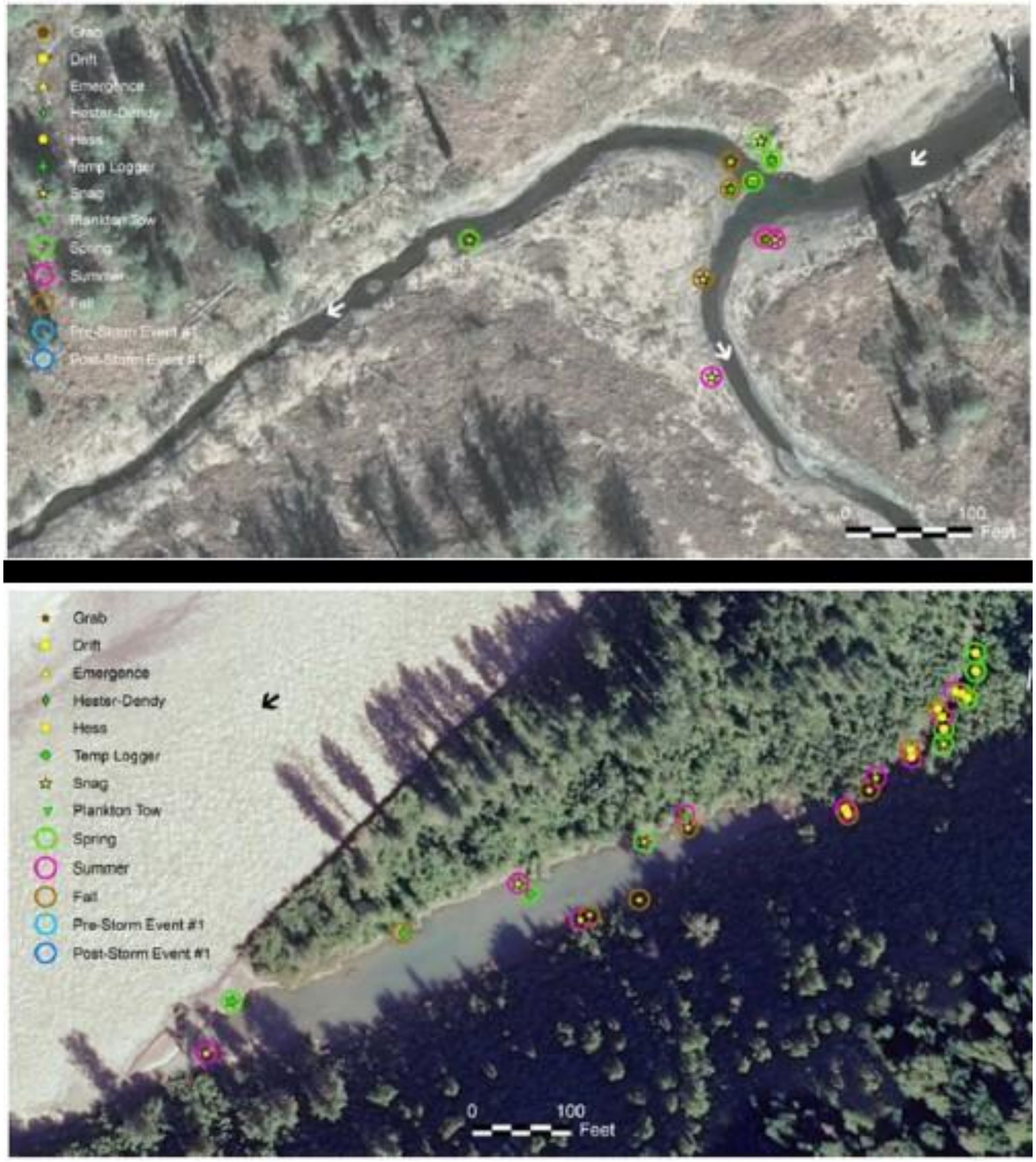

Figure 5. Sampling locations in the FA 104 Focus Area upland slough (upper photograph). All benthic grab and drift samples were collected from the same location within this macrohabitat. This in not the accepted scientific practice nor consistent with the approved plan. Lower photograph shows the upland slough in FA 144. Samples in this FA 144 slough were not collected in the dominant backwater habitat but were concentrated in riffle habitat at the upstream end, to facilitate use of a Hess sampler.

Benthic and algal samples were collected from an upland slough sampling unit in FA 104, however all sample replicates were collected from the same location (Figure 6). The IP states that samples will be distributed equally over the 200 m sampling unit. Therefore, sampling was not conducted as provided for in the approved plan. Sampling results for this site are not adequate to meet this study.

Figure 6. Orignal ISR classification of FA 173 (top), most recent classification (middle) and aerial photograph of FA 173 (bottom). FERC determination recommended sampling all macrohabitats within River Productivity focus areas. Lower right is an upland slough habitat that was not sampled by AEA. Arrow in upper middle of photograph side slough habitat (clear water and disconnected) that was misidentified, sampled, and reported as side channel habitat.

Sampling locations within the FA 141 upland slough sampling unit appear to be inappropriately selected based on the ability to collect samples using a Hess sampler, and to collect algae from cobble substrate at the upstream end of the slough (Figure 6), although conflictingly, SIR Table 4.8-1 states that both Hess and Ponar samplers were used to collect samples. No drift was sampled and it is not possible to determine which substrate was sampled to collect algae. The upland slough backwater is dominated by fine substrate and deep water thus sampling is not representative of this habitat and instead seems to have been conducted for the ease of sampling using primarily a Hess sampler rather than to adequately sample this habitat as necessary. In addition, replicate samples were all collected within close proximity to each other; particularly during spring and summer. Therefore, sampling was not conduced per the study plan. Benthic and algal sampling results from this site can't be used to meet the objectives of the study plan and sampling must be repeated per the approved study plan's methods. Benthic, algal, and drift samples must be distributed evenly throughout the 200 m sampling unit and appropriate methods should be used for the substrate types and water velocity.

The FA 141 upland slough River Productivity sampling unit was not co-located with fish sampling from the FDA study (see AEA ISR 9.6 Appendix A). FDA sampling occurred in the large upland slough beaver complex on the right bank upstream from Indian River while River Productivity sampling occurred in an upland slough on the left bank. No Coho Salmon >50 mm were captured in this slough by the River Productivity Study (see SIR table 4.7-1,2,3 and FDA_CD_Fishcapturetag).

Upland slough habitat was available in FA 173 but was not sampled (Figure 7). FERC recommended sampling all macrohabitats within all focus areas selected for River Productivity sampling. River Productivity sampling within the upland slough in FA 173 must be conducted per the study plan in subsequent study.

Figure 7. Aerial photograph of Montana Creek showing side slough macrohabitat that was not sampled . The study plan required sampling all macrohabitats within every focus area or Lower River sampling reaches.

Current and historic studies indicate that upland sloughs are one of the most productive habitats for rearing Coho and Chinook Salmon. AEA ISR 9.6 reported juvenile Chinook Salmon as being most abundant in the upland sloughs of FA 115 and FA 141. However River Productivity sampling did not occur in either of these sloughs. Upland sloughs, located on the lateral margins of the main-stem channel, will be the macrohabitats most affected by water storage and flow fluctuations from operation of the proposed Project. River Productivity sampling from two upland sloughs is insufficient to document the macroinvertebrate and algal communities within these macrohabitats, particularly as no Coho Salmon were captured in the upland slough in FA 144. Additional upland slough sampling is necessary to meet study objectives. In addition to sampling conducted in FA 104 and FA 141, we request the upland sloughs in FA 115 (Slough 6A), FA 138 upland sloughs, and FA 144 upland slough (right bank) be sampled for benthic invertebrates, invertebrate drift and periphytic algae using appropriate sampling methods as provided for in the study plan. This would provide five replicate upland slough sampling units within the Middle River below Devils Canyon.

Modification 2-2: Side slough sampling units and sampling locations within side slough sampling units must be selected as provided for in the study plan. Additional Middle River side slough sampling units must be selected and sampled below Devils Canyon.

The FERC study determination (April 1, 2013) recommended sampling all macrohabitats that occurred within a Middle River focus area and Lower River sampling areas be selected for River Productivity sampling. AEA moved the Lower River Trapper Creek sampling area to the Montana Creek area but did not sample available side slough habitat there (Figure 7). Within side slough sampling units all five “replicate” samples were collected from the same location (Figure 8a). This sampling did not implement the study plan; accepted scientific practice is to distribute sampling locations randomly or systematically through the sampling unit of 20 x channel widths.

Figure 8a. AEA FA 104 habitats sampled by the River Productivity study and reported as side slough. The location in the upper photograph clearly shows that most of the samples were collected within Whiskers Creek which is a tributary, not a side slough. The FA 104 side slough (lower photograph) is the singe River Productivity sampling site of this macrohabitat type that overlaps with the distribution of rearing juvenile salmon and one of only two side slough sites on the entire Susitna River sampled by AEA.

Study results from FA 104 were collected within Whiskers Creek and presented as being representative of side slough macrohabitat. All summer and fall samples were collected within Whiskers Creek, which is a tributary and not a side slough macrohabitat (Figure 8a, upper panel). This site also is not a tributary mouth as tributary mouths must discharge into main channel or side channel habitat (see definitions in AEA 9.9). In addition all five springs and summer replicates were collected from the same location and were not distributed throughout the sampling unit as described within the study plan. The study results for this sampling location should not be used; they do not meet the study objective.

River Productivity sampling was conducted in only two side sloughs to represent the entire Susitna River and only one of these side sloughs (FA 104) was downstream from Devils Canyon overlapping with the distribution of most anadromous fish species. In addition, the short side slough at FA 104 is very dissimilar from the side sloughs in FA128 and FA138. The adult escapement and FDA studies have identified side sloughs as the macrohabitat that provides main-stem spawning habitat for Chum, Sockeye, and Coho Salmon and rearing and overwintering habitat for Chinook, Coho, and Sockeye Salmon. These lateral habitats likely will be affected by water storage during the spring and winter load-following releases. The importance of these relatively shallow and clear water habitats may be due to greater primary and secondary production augmented by marine sources of nitrogen and phosphorus. However, River Productivity sampling was only conducted in one side slough for the entire Susitna River downstream from Devils Canyon (two in total including one in FA 173), and salmon spawning has not been documented in the FA 104 side slough sampled. The level of effort is inadequate for these important habitats and a proposed project of this magnitude.

River Productivity sampling must be conducted at a minimum of six Middle River side slough macrohabitats below Devils Canyon. In addition to FA 104, sampling the side slough in FA 114 (misclassified by AEA as a side channel), the side slough in FA 128 that has been the location where AEA has expended the most amount of effort and which is an important spawning channel, the side slough in FA 138 which also is an important spawning channel, the side slough just downstream from Indian River in FA 141 (Figure 8b), and the side slough at the upstream end of FA 144. This is consistent with the FERC determination (April 1, 2013) that estimated five replicates of each macrohabitat based on their review of AEAs revised study and implementation plans.

Figure 8b. Side slough and side channel habitat just downstream from the mouth of Indian River and Focus Area 141. Only one side slough was sampled for the River Productivity Study downstream of Devils Canyon. AEA did not sample this side slough habitat downstream from the major Middle River Chinook and Coho salmon spawning tributary since it did not fall into the boundaries of the Focus Area. AEA did not sample this side channel habitat, instead sampled as small ephemeral channel at the downstream end of an island (see Figure 10).

Within these side sloughs and all River Productivity sampling units, sampling locations sampling reaches should be established that are consistent with FDA sampling reaches at 20 x channel width. Sampling locations within these sampling units should be stratified separating sampling locations by at least one or more channel widths.

Modification 2-3: Benthic invertebrate, organic matter, and algal samples collected at the side channel sampling units in the ISR must not be not used to address study objectives. Correct this sampling irregularity by selecting and sampling side channel sampling units that are representative of this macrohabitat type ensuring that sampling locations within the side channel sampling units are distributed throughout the 500 m sampling unit as provided for in the study plan.

Sampling was not conducted at sampling units which were representative of side channel habitats, and sample locations within these units were not selected per the study plan but instead were all collected within close proximity to each other. Figure 9 shows the FA 184 sampling units and sampling locations selected by AEA. The side channel and main channel sampling units and all sampling locations were collected from the head of a single island. Samples collected from this site do not clearly represent main channel or side channel habitat and will preclude detecting significant differences among macrohabitat types. Figure 9 shows the side channel sampling site for FA 173, which based on AEAs classification methods, is a side slough. Figure 10 shows the side channel site selected for FA 141 which is an ephemeral channel on the downstream end of an island that is frequently dewatered. Figure 8b shows available side channel habitat just downstream from the Indian River that could have been selected for adequate sampling. Figure 12 shows the side channel site selected in FA 104 that is just downstream from an upland slough and at flow levels used for habitat characterization (10,000 to 12,000 cfs) is within the clearwater upland slough habitat. The only true side channel sampled was RP-81-4, and at this site all samples were inappropriately collected from approximately the same location (AEA ISR Appendix B Figure B-4). Unrepresentative side channel sites were selected within each focus area; however, there were abundant alternative side channel habitat sites available which could have provided adequate sampling. Therefore, there are no macroinvertebrate or chlorophyll-a results that are clearly representative of this macrohabitat type, even though side channels are a common Middle River macrohabitat type.

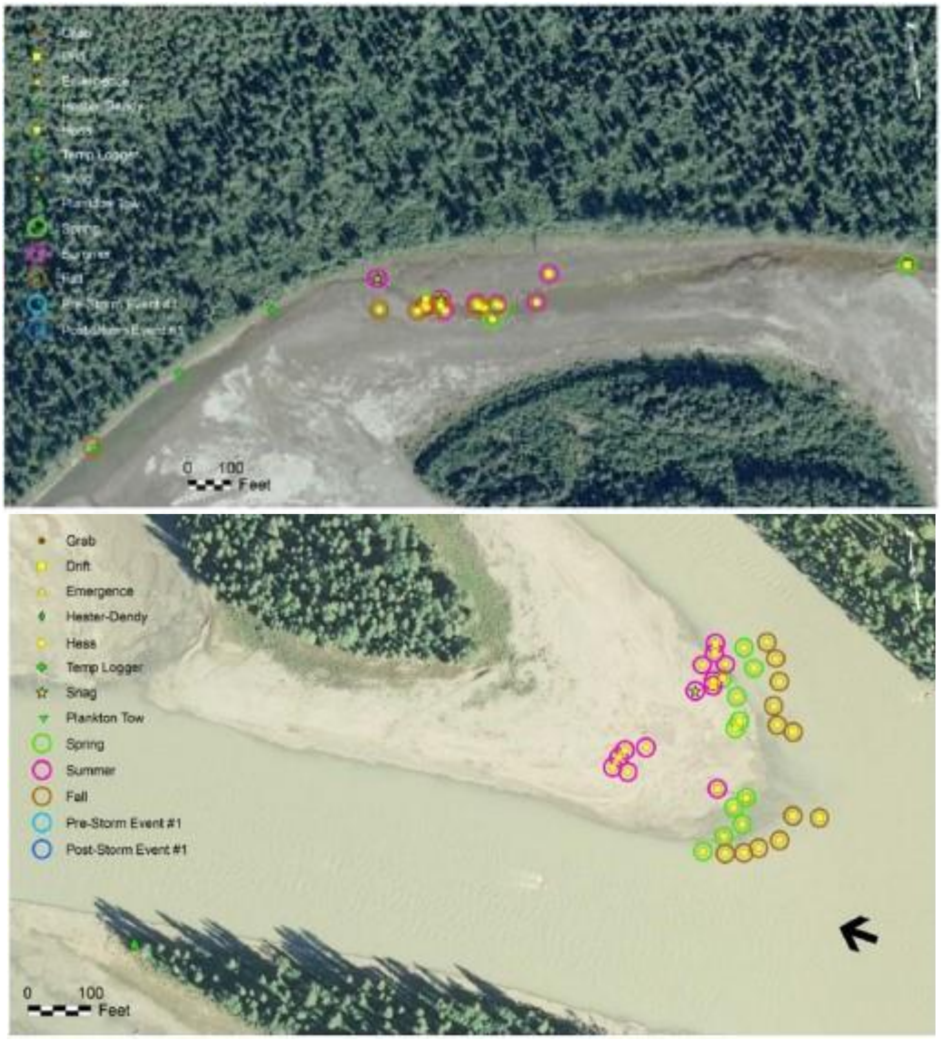

Figure 9. AEA River Productivity sampling locations in FA 184 (top). All of these samples collected from the same point bar are supposed to represent two different unique macrohabitats, main channel and side channel. All of the sample replicates are collected within feet of each other, which is not the accepted scientific practice and will not provide replicate measures of different habitat conditions necessary to develop habitat suitability models, one of the study objectives. Sampling site in FA 177 was reported as side channel (bottom photograph); however, it is clearly side slough habitat. Samples are all taken from approximately the same location.

Within each side channel sampling unit all sampling locations were selected in close proximity to each other instead of distributing the locations systematically as provided for in the approved plan. Side channel sampling sites for the FDA study are 500 m long and the accepted scientific practice is sampling units of 20 times channel width (i.e. Moulton et al. 2002). The Final River Productivity IP states that benthic sample will be collected from five “suitable locations, spacing them as equidistantly as possible, to be representative of the site. If five unique and separate locations are not available, it will be necessary to collect more than one sample within the same location. If this is the case, space the sample locations out as far as possible. For example, if conditions require two samples in one riffle area, sample at the downstream end and then the upstream end. As a general rule, samples should not be taken within 10 m of each other. Selected locations at each site should be sampled in a downstream-to-upstream direction." For a 500 meter sampling unit sampling locations could have been separated by 100 m. However at a minimum, according to the implementation plan, samples should not have been collected from the same riffle and should have been at least 10 m apart. Review of Figures 10 through 14 illustrates that all samples were collected on the same point bar (FA 184 and FA 141) or riffle (FA 104).

Figure 10. Upper photograph showing habitat within Indian River Focus Area (FA 141) selected by AEA to represent side channel habitat. The classification of this habitat does not meet the definition for side channel habitat and the site is frequency dewatered as shown in the lower photograph which was taken from AEA's habitat characterization aerial video. This location is upstream from the mouth of Indian River and was not sampled by the FDA Study 9.6. This location is one of two Middle River side channel sites downstream from Devils Canyon.

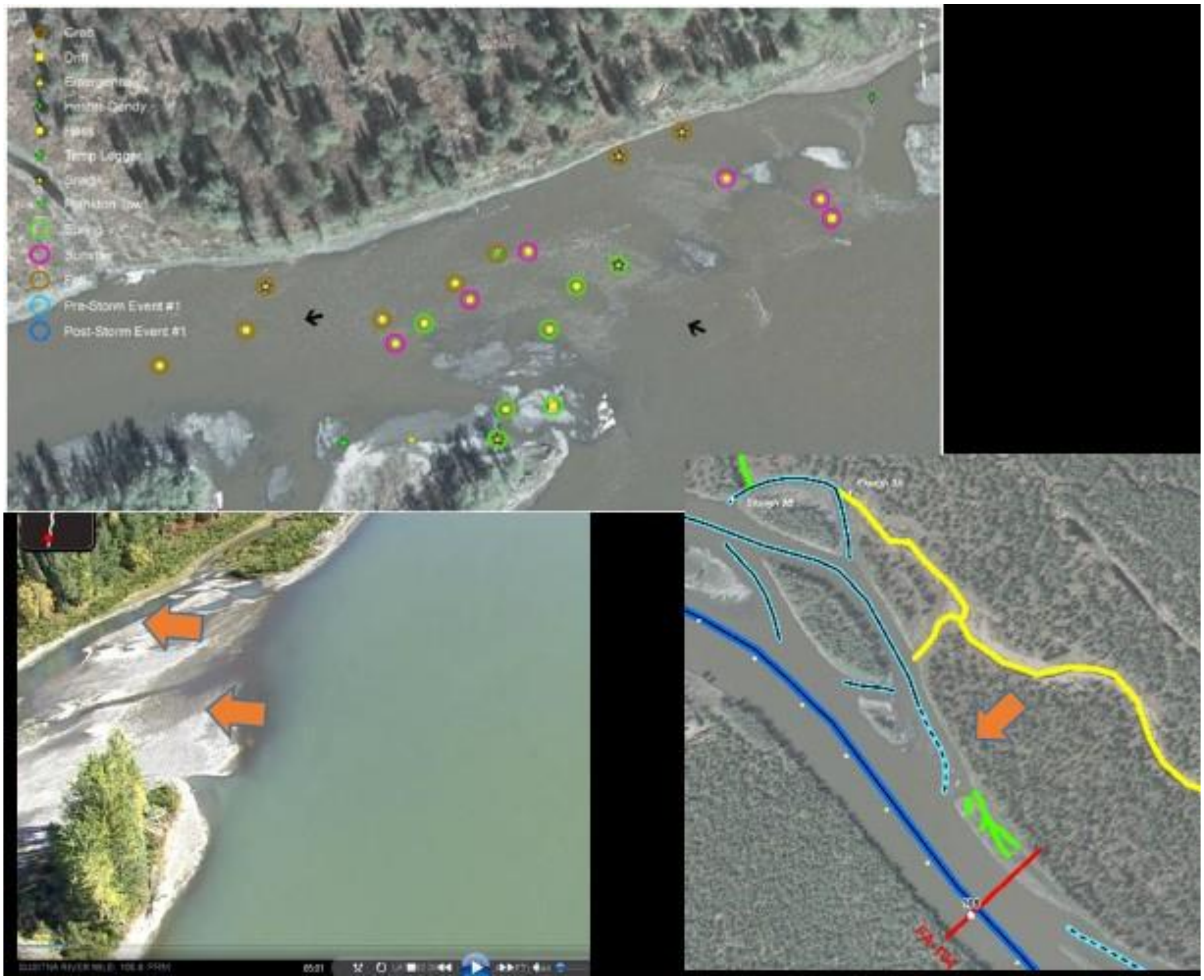

Figure 11. Location selected in Focus Area 104 by AEA to represent side channel habitat (top photograph). Even though side channel habitat is extensive in this Focus Area (right), a sampling site was selected that is often dewatered. During low flows clear water from the side slough extends downstream overlapping productivity sampling sites. This location is not representative of side channel habitat and should not have been selected by AEA for productivity sampling. Sample site selection was likely based on the need to sample rifle habitat with the Hess sampler.

Benthic invertebrate, benthic organic matter, benthic algal sample results from samples collected from the sampling units and locations as reported in the ISR for side channels should be discarded and sampling repeated. During the second study year, side channel sampling units that are representative of this macrohabitat type must be selected and appropriately sampled. A minimum of 6 side channel sites must be sampled downstream from Devils Canyon. These should include side channel habitat in FA 144 and FA 141, side channel habitat below Montana Creek identified in Figure 13, side channel habitat in FA 138, side channel habitat in FA 138, side channel habitat in FA 115 or 114, and side channel habitat in FA 104 which is not within the upland slough or other macrohabitat type.

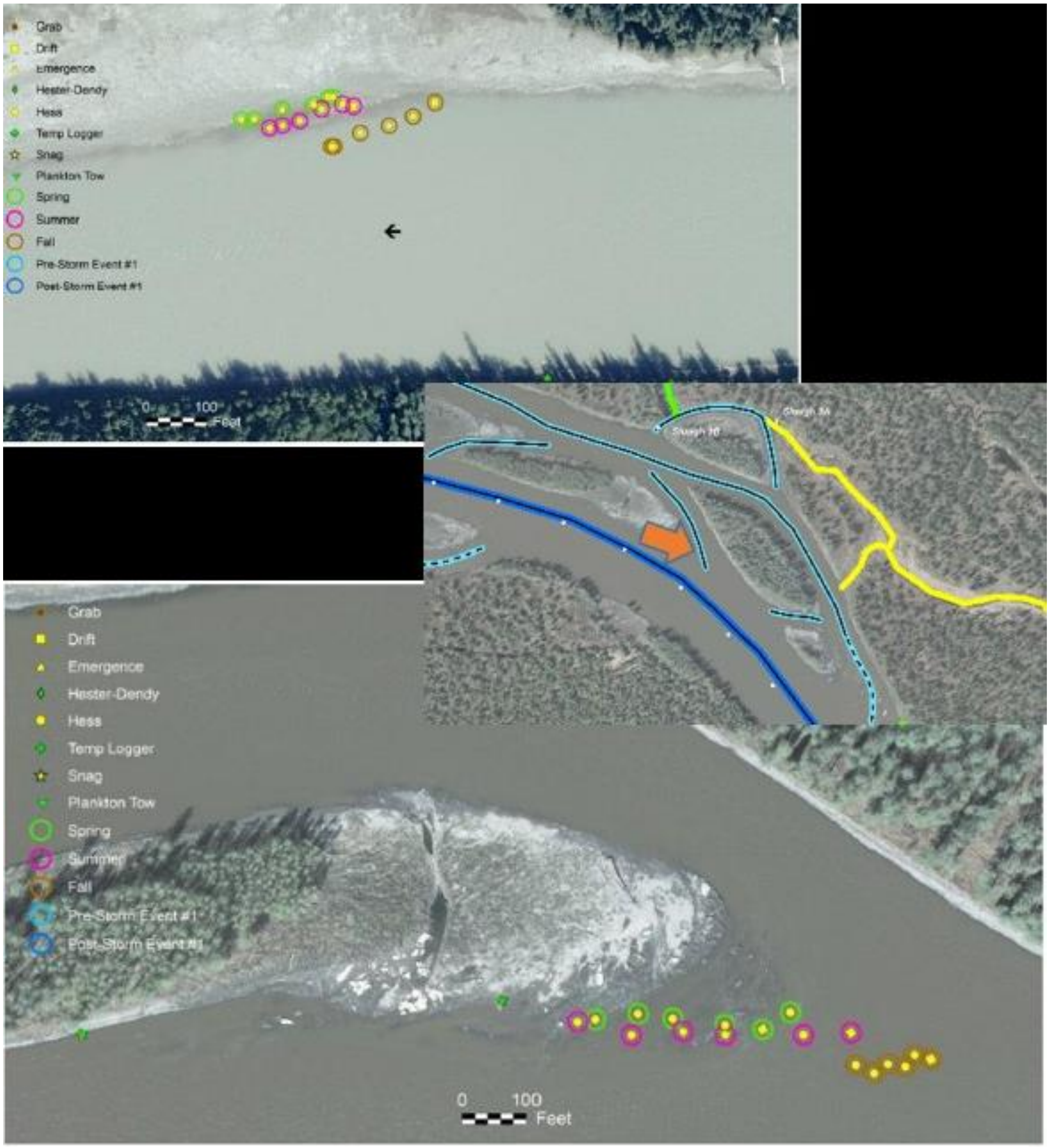

Figure 13. Benthic sampling locations in FA-173 main channel productivity sampling unit (top). All sampling locations are in close proximity to each other and are not distributed throughout the sampling unit as provided for in the approved plan. Sampling locations are in shallow water that was likely dewatered within 30 days prior to sample collection. Benthic sampling locations in FA-104 main channel sampling unit (bottom photograph). Inset is AEA habitat classification from Study 9.8 for FA-104. Based on classification many sampling locations are within side channel and not main channel macrohabitat. All sampling locations on each sampling date are not distributed throughout the sampling unit as provided for in the approved plan.

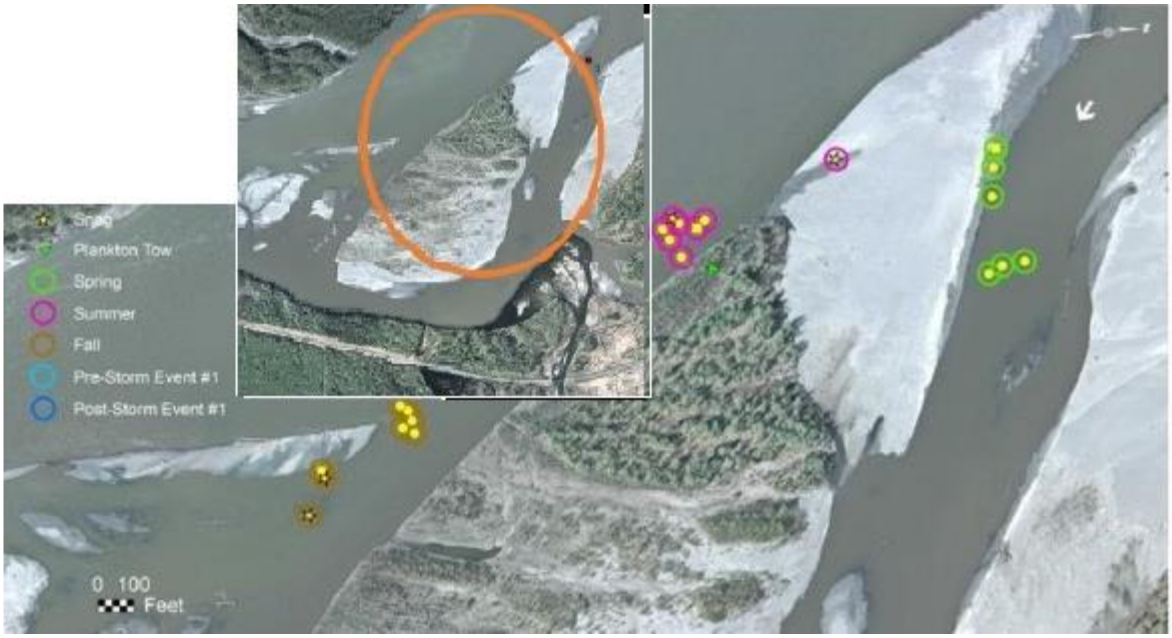

Figure 14. AEA productivity sampling locations in RM 81 (Montana Creek) sampling unit selected to represent main channel habitat. "Spring" samples (June 29 and 30) were collected from side channel habitat (see aerial photograph insert). During each sampling event, all five replicates were collected from the same location and not distributed throughout the sampling unit as provided for in the approved sampling plan. Side channel habitat was not sampled on all sampling dates even though it is present in the study area.

Modification 2-4: Benthic invertebrate, organic matter, and benthic algal samples collected at the main channel sampling units are erroneous and must not be used to address study objectives. To correct, select main channel sampling units that are representative of this macrohabitat type, sampling locations within the main channel sampling units that are distributed throughout the 500 m sampling unit per the study plan.

A main channel sampling unit must be selected within each focus area to provide a minimum of six replicate samples. Sample locations should be distributed throughout the 500 main channel sampling units, as per the study plan, and must not be collected from the same point bar, riffle, or island.

Main channel sampling units were not selected by AEA that were clearly in main channel macrohabitat types and all samples within these sampling units were collected in close proximity to each other. Figure 9, shows FA 184 main channel sampling locations, and figures 13 through 14 show main channel sampling locations for FA 173, FA 104 and Montana Creek. Main channel sampling units were not selected that are representative of the macrohabitat type, sampling locations were not distributed throughout the sampling unit as provided for in the approved plan, and sampling units were often dewatered within 30 days prior to sample collection. These are all variances from the study plan and impair the ability of the study to meet objectives. They must be rectified.

Main channel sampling locations in FA-184 were on the same point bar as samples collected to represent a side channel (Figure 9). Sampling locations reported by AEA to represent FA-104 main channel habitat and during spring sampling in RP 81, were located in a side channel. In FA-141 AEA did not sample main channel habitat even though this macrohabitat type was present within the FA thus the approved sampling plan was not implemented. Main channel is the dominant macrohabitat type; however, only one productivity sampling unit was sampled which was clearly located within main channel habitat.

AEA did not distribute sampling locations within main channel sampling units as provided for in the study plan. Similar to other sampling units, all sampling locations were within close proximity to each other.

Modification 2-5: Collect macroinvertebrate samples from locations and depths that are within the active channel under most flow conditions and for main-stem and side channels alternative methods need to be employed including dome samplers and SCUBA if necessary (see NMFS RSP comments (March 18, 2013). Hess samplers should not be used, as they cannot sample at these depths.

NMFS expressed concern during study plan development and provided formal comments the proposed and revised study plans about the inappropriate the use of a Hess sampler to collect macroinvertebrates on large rivers. Hess samplers cannot sample at depths greater than approximately 1.5 feet. Hess sampler use is not the accepted scientific practice for macroinvertebrate sampling in large rivers because of this depth restriction. Use of a Hess sampler results in sample collection in locations that are not representative of the macrohabitat under investigation, samples being collected from areas that were recently dewatered, and does not provide the range of depths and substrates necessary to develop Habitat Suitability Criteria/Habitat Suitability Indices. FERC in their study determination (April 1, 2013) stated, "…AEA should select the most appropriate sampler according to the bottom substrate, water velocity, and other conditions (see Klemm et al. 1990), but should endeavor to use the same sampler in all macrohabitats of this type to ensure consistency among samples. Additionally, AEA should sample benthic algae on cobble substrates at multiple depths up to 3 feet (e.g., depth categories of 0–1 foot, 1–2 feet, and 2–3 feet) at each macrohabitat site (main channel, tributary confluences, side channels, and sloughs), to the extent feasible given the limits of field safety."

ISR results from the 2013 sampling validate NMFS concerns. Most of the sampling sites were not inundated 30 days prior to sampling. Only riffles were sampled, which (based on results in Study 9.9, Habitat Characterization and Mapping) accounts for < 5% of main-stem and side channel habitat (Table 4. Middle River Technical Memorandum). Our review of the depths for Hess samples (ISR_9_8_RiverPro_Hessdepthstage), shows that all of the samples were collected in water depth < 1.5 ft, and 75% of the samples were collected in water depths of 0.7 ft or less. Since algal samples were collected in front of each Hess sample, benthic macroinvertebrate and algal samples were not collected from multiple depths up to 3 feet as FERC required.

Sampling methods among macrohabitat types were not consistent, as was required by FERC. For example, figure 6 shows sampling locations in an upland slough sampling unit where sampling was moved to the upper portion of the slough to sample riffle habitat with a Hess sampler even though a dredge or grab sampler was used in other upland sloughs.

The use of a Hess sampler likely also explains why samples were collected from tributary deltas and not tributary mouths as required, and from the head of islands and other sampling locations with shallow water depths which are not representative of the macrohabitat. Tributary deltas are shallower and allow for use of a Hess sampler, however, tributary mouth habitat, including the downstream plume are often deep and would require a sampler designed for these habitats (Figure 1 through 3). The habitat sampled in FA 141 as a side channel appears to have been selected due to shallower water depth conducive to the use of a Hess sampler, however, this resulted in samples being collected from habitat that is frequently dewatered and not representative of Susitna River side channels (Figure 10). The locations selected to represent side channels and main channels also were located on island point bars in FAs 81, 104, and 141, which are shallow, allowing for the use of a Hess sampler, are often dewatered and are also not representative of these macrohabitat types nor does this sampling comply with the study plan objectives or intended use of the data.

Modification 2-6: Collect invertebrate and algal samples from sites dominated by fine substrates so that the samples are representative of the dominant habitat per the study plan.

Algal samples collected in 2013 from cobbles substrates in sampling units dominated by fine substrates should not be used to evaluate food resources among macrohabitats.

FERC's approved sampling plan requires testing for differences in algal abundance (as indicated by concentrations of chlorophyll-*a* and AFDM) among macrohabitat types. Backwater habitats at the mouths of upland sloughs, side sloughs, and tributary mouths are often dominated by fine sediments. Water velocities and water depths vary between sites with cobble and fine substrates, and cobbles provide a more stable algal substrate. Since water velocity influences nutrient availability, algal sloughing and light availability varies with water depth, particularly in brown-water upland slough habitats. It is reasonable to hypothesize that algal abundance will be different between these two substrate types. Chlorophyll-*a* can easily be extracted from fine sediment samples however they are sampled (i.e. petri dish, cores, etc.). Fine sediment samples can easily be dried and organics burned to determine AFDM. FERC's recommendations for sample collection are feasible must be implemented adequately for study results to be accurate and useful.

Modification 2-7: Collect algal samples from multiple depths (0-1, 1-2, 2-3 feet) within each macrohabitat, proportional to the depths present and such that all sites are inundated for 30 day prior to sampling per the study plan.

The FERC study determination (April 1, 2013) required that algal samples be collected from multiple depths in order to determine a relationship between light availability and primary production and for Habitat Suitability Criteria/Habitat Suitability Indices development. Collecting cobbles or sampling fine sediments from depths up to three feet is feasible; however samples were not collected from these depths. Most of the sampling locations were also not inundated for 30 days prior to sampling as required, primarily in main channel and side channel habitats. This has a large effect on algal chlorophyll-a concentrations in these habitats. Algal samples must be collected from multiple depths as provided for in the approved study plan at sampling locations that have not been dewatered during the previous 30 days during the second study. Algal chlorophyll-*a* and AFDM values from samples that were dewatered within 30 days prior to sampling do not meet study objectives and can't be used.

Modification 2-8: Collect benthic macroinvertebrate and algal samples during the spring, summer, and fall sampling periods for a minimum of two years as described in the study plan. Spring sampling must occur prior to June 1, and Fall sampling in October.

Spring and fall sampling represent time periods when glacial melt is low resulting in low stage heights and low turbidity, potentially mimicking post-project conditions. It has been reasonably hypothesized that primary production is high during these periods of greater light availability. During late fall, decreases in light are accompanied by increases in nutrient availability from decaying salmon carcasses resulting in visual increases in algal abundance (Figure 15). Creating a 42 mile-long reservoir on the Susitna River is likely to result in reduced turbidity in the Middle Susitna River which may result in an increase in primary productivity. Therefore it is important to conduct benthic invertebrate and algal sampling during spring and fall time periods of low turbidity.

Figure 15. Extensive biofilm on gravel and cobble substrates in side channel habitat on October 26, 2015, with low turbidity and numerous salmon carcasses. Fall productivity sampling was completed prior to fall reductions in main channel and side channel turbidity. The AEA River Productivity IP stated that invertebrates, algal, and drift samples would be collected in the Spring (April – early June), Summer (late June through August), and Fall (September through October) (IP page 47). Sampling was not conducted as provided for in the approved plan. AEA conducted their "Spring" sampling between June 19th and July 18th 2013. Summer samples were collected

August 12th through August 29th 2013. Fall samples were collected September 22nd through October 3rd 2013. Spring breakup occurred very late in 2013, one indication of anomalous environmental conditions. Samples collected late, from the middle of June through the middle of July are not representative of spring conditions and were not conducted prior to increases in summer turbidity. Fall samples were collected early, during late September when turbidity was still high. For example, on October 9, 2015 main-stem turbidity was measured by NMFS at ~36 NTU in a side channel of the Susitna River; by October 27, 2015 turbidity was near 1 NTU at the same location (Figure 15). Therefore, sampling did not measure potential increases in primary productivity during early spring and fall per the study plan.

Modification 2-9: Samples of invertebrates which were collected when traps were out of the water for the invertebrate emergence study must not be used in any evaluation of emergence among macrohabitats or sampling sites.

The macroinvertebrate emergency study must be repeated to obtain adequate replication among all macrohabitats. At a minimum there should be five replicate sampling locations distributed within the 200 or 500 m macrohabitat sampling unit. Sampling should be conducted within sampling units that are located in five distinct macrohabitats of each of the five macrohabitat types (main channel, side channel, side slough upland slough, and tributary mouth). Samples need to be collected in the spring prior to breakup to coincide with the emergence of juvenile salmon as provided for in the approved plan.

Emergence traps were not deployed in the spring prior to breakup, and traps were not emptied every two weeks as required by the study plan. Acceptably useful data were not obtained from many of the sites and like other study objectives; sampling sites did not provide adequate replication of macrohabitats. Many of the emergence traps deployed in 2013 were found out of the water or damaged when traps were checked (AEA SIR Table 4.3-2). The duration that these traps were functional is unknown. AEA calculated emergence results assuming duration for the total time period, which will underestimate results for that time period as they were not collecting emergent insects after they were out of the water, which could have been for as long as two weeks. Emergent insects from these traps should not have been processed, and results from these traps should not have been reported. Results from these traps must not be used in estimating emergence of aquatic insects. The traps that were intact were deployed for far longer than the two week trapping period specified in the implementation plan (middle of June to early August). Given these variances from the study plan methodology which resulted in non-standard data collection we conclude that this study as implemented is unable to evaluate differences in emergence timing or insect production among sites or macrohabitats relative to water temperatures or flow variability and must not be used for those evaluations.

Additional sampling concerns are: that only one emergence trap was installed at each macrohabitat; traps were not placed randomly within each macrohabitat; results from one trap may or may not be representative of the macrohabitat under investigation. Similar to benthic sampling, replicate samples need to be collected within each macrohabitat to provide a mean value representative of the sampling unit. This is of particular importance as trap locations may not be selected randomly, and one or more traps may become dewatered or damaged between collection intervals. Water temperature also was highly variable within and among sampling units (AEA SIR) which would likely lead to differences in emergence time and production. Multiple traps would provide a method to access this variability and may provide some data in the event that one or more traps are damaged between visits.

Objective 3: *Estimate drift of benthic macroinvertebrates in selected habitats within the Middle and Lower Susitna River to assess food availability to juvenile and resident fishes.*

Modification 3-1: Invertebrate drift must be measured upstream and downstream from tributary mouths as provided for in the approved study plan during the second year of sampling.

If invertebrate drift is measured in the tributary, tributary discharge also must be measured to allow for adequate estimation of the relative contribution of a tributary to main-stem food availability.

FERC in their study determination (April 1, 2013) stated that: "macroinvertebrate drift sampling upstream and downstream of tributaries would provide information needed to assess the relative contribution of tributaries and the main-stem Susitna River to fish food resources" (section 5.9(b)(4)). This information would inform the assessment of fish food availability, which is among AEA's stated study objectives, and can be used to evaluate the potential effects of project-related changes in macroinvertebrate drift on fish food resources in the Susitna River (section 5.9(b)(5) and (7)). We anticipate that bracketing the tributary mouths for drift sampling would require little or no additional effort relative to AEA's proposed drift sampling methods, and as such any associated costs would be minimal (section 5.9(b)(7)). We recommend sampling macroinvertebrate drift upstream and immediately downstream of tributary mouths to collect information needed to assess the relative contribution of tributaries and the main-stem Susitna River to fish food resources."

Main-stem or side channel drift samples were not collected downstream of tributary. The sampling locations presented in AEA Figures 4.2-1, 4.2-3, 4.2-4 and 4.2-5 (ISR Part A Page 55-61) show that tributary sampling did not occur both upstream and downstream at any station's tributaries (Tsusena Creek, Indian River, Whiskers Creek, or Montana Creek). Instead tributary sampling occurred within the tributary itself, not in the main-stem downstream. The concentration of drift downstream from tributaries within or below the mixing zone will represent the combination of main channel and tributary sources. Sampling below tributaries will account, to varying degree, for differences in tributary and main-stem drift concentration and discharge. With samples collected in tributaries, AEA also needs measures of tributary discharge to calculate a drift value (flux) that can be used to compare with main-stem values and that can be used to assess tributary influence on food availability. A high concentration of invertebrates in the drift may have little contribution to main-stem food availability under low tributary discharge flux rates (discharge x concentration). However, tributary discharge was not measured during sampling and tributary contribution to main-stem food availability cannot be calculated.

Modification 3-2: Drift sampling must be conducted every four hours in one or more of each representative macrohabitat to determine diel variation in drift during each sampling event.

During the first year of study, macroinvertebrate drift was collected concurrent with benthic and algal sampling. This resulted in drift samples being collected during different times of the day, from morning to early evening. However, it has been well established that drift density and the size of drifting organisms can very over a 24 hour period (Hauer and Lamberti 2006). The time of peak drift may also vary seasonally due to the large differences in day length, especially in this subarctic location. The evaluation of differences in invertebrates drifting in the water column or zooplankton can be obscured by variability caused by diel differences in drift abundance. Similarly, differences in drift density and composition could alter bioenergetic modelling predictions of consumption.

The IP stated that diel drift did not need to be accounted for due to the dominance of Chironmids and citation of a study which found that during the long summer in northern latitudes, diel drift patterns may be disrupted. However, results from 2013 show that while Chironomids may have the highest relative abundance, they rarely account for more than 60% of drift samples in numbers, and likely far less in biomass (SIR Table 5.2-1). Spring and autumn sampling also occurs during times of distinct photoperiods.

Many invertebrate species exhibit high rates of downstream drift associated with diel periodicity. Many are night-active, for which light intensity is the phase-setting mechanism but this can also be influenced by chemical triggers from potential predators (see McIntosh et al 2002); but some are day-active, for whom water temperature may be the phase-setter (Waters 1969). Diel patterns consist of one or more peaks, occurring at various times of the 24-hour period depending on the species (Sagar and Glova 1988).

Magnitude of the drift is often a function of water temperature, current velocity, stage of life cycle, population density and growth rates. Disturbances, either natural (e.g., flood) or anthropogenic (e.g., pulsed flows) can have a significant effects on stream drift (Lake 2000).

In turn, feeding activity in stream fishes is greatly tied to energy efficiency with a hierarchy of fish selecting optimum foraging sites, typically associated with drift feeding stations. However, feeding rate and location within the 24-hr period also changes dramatically depending on water temperature, light availability, drift rates, and competition, etc. Sampling only within daylight periods is likely to miss key aspects of drift relevant to identifying and describing drift in relationship to fish diets. Perry and Perry (1986) found dramatic changes in invertebrate drift during and following flow manipulation related to rate of flow change and time of day. Therefore, not including samples of drift throughout the 24-hr period as it relates to season, storm events etc. does not provide a baseline for which to compare against anthropogenic disturbance.

Sagar and Glova (1988) studied the diel feeding periodicity, daily ration and prey selection of juvenile Chinook Salmon in relation to the available prey. Maximum food intake (dry weight) occurred about dawn, when mayflies were the major prey, but the greatest number of freshly eaten prey occurred during the afternoon, when Chironomids and terrestrial Dipterans predominated. Feeding activity at night was low, with smaller mayflies comprising up to 50% of prey. During the day young salmon fed selectively on Chironomids and the larger mayflies, while Trichopterans and terrestrial taxa were under-represented in the diet. Food consumption over the 24-h period averaged 8.3% of the fish dry body weight. Prey abundance in the drift explained about 50% of the composition of the diet. Although the fish selected larger mayflies, size apparently was not a main criterion for selection because Chironomids, although smaller than mayflies, were also frequently eaten. Previous dietary experience of the fish and the diel pattern of prey abundance appear to best explain the selective feeding of juvenile Chinook Salmon. Johnson, and Johnson (1981) observed clear segregation in feeding timing of Coho Salmon and Steelhead Trout suggesting a mechanism to avoid competition.

Considering the clear periodicity observed in numerous studies of stream salmonid and other fish species' diets, NMFS recommends this study be modified so that the variability in drift over a 24 hour period is evaluated in one of each of the five macrohabitat types during spring, summer, and fall sampling.

Modification 3-3: Study methods must be modified to use finer mesh when conducting tows in slow water habitats in order to estimate the contribution of zooplankton as a food resource in these habitats.

NMFS recommends this study modification based on AEA's initial results that identified zooplankton as a major component the stomach contents of fish species. Based on the first study year, zooplankton also appears be a significant food source in stillwater habitats of upland sloughs, side sloughs, and main-stem macrohabitats (SIR Table 5.2-1). Tow samples collected in low velocity habitats should use a fine mesh net of 50 µm or less, consistent with the EPA National Lake Assessment methodology (EPA 2012) allowing for the collection and identification of macrozooplankton. Enumeration and biomass estimates of macrozooplankton should use the EPA methodology cited.

Objective 4: *Conduct a feasibility study in 2013 to evaluate the suitability of using reference sites on the Talkeetna River to monitor long-term Project-related change in benthic productivity.*

Modification 4-1: Modify the study so that reference sampling in the Talkeetna River provides replicate measures of all five of the major macrohabitats (main channel, side channel, side slough, upland slough, and tributary mouth).

During 2013, AEA collected benthic, drift, algal and organic matter samples from a side channel, side slough, and upland slough habitat. It is currently unknown whether potential project effects will have a greater effect on one or more of the Susitna River macrohabitats. Tributary mouths, side sloughs and upland sloughs may be most affected by water storage, whereas main channels and side channels may be most affected by changes in organic matter transport, turbidity, and water temperatures. It is unlikely the full extent of project affects can be accurately predicted, however, it is likely that physical, biotic, and chemical characteristics in all macrohabitats will be altered to some degree. Since Susitna River sampling is designed to characterize conditions in all five major macrohabitats, this same sampling design must be implemented in the Talkeetna River in order to provide a measure of the reference condition.

Objective 5: *Conduct trophic analysis to describe the food web relationships within the current riverine community within the Middle and Lower Susitna River.*

Modification 5-1 (a-e): We request the following substantial modifications to the Growth Rate and Growth Rate Potential Modelling study:

a. Refine study objectives using bioenergetics modelling to evaluate the pre- and post-project influence of temperature, water velocity, food availability and food quality on juvenile Coho and Chinook Salmon at five or more replicate Middle River main channel or side channel, tributary mouth, side slough, and upland slough macrohabitats.
b. Macrohabitats should be located within Middle River focus areas below Devils Canyon to take advantage of 2D hydraulic modelling and to overlap with the distribution of juvenile salmon. However, not all macrohabitats within a focus area need to be sampled as long as there are five or more replicates of each macrohabitat type. These macrohabitats are most likely to support rearing juvenile Coho and Chinook Salmon, and vary in temperature, water velocities, and macroinvertebrate species.
c. Conduct the study between July and early September. Sampling during this time period will reduce effort and allow time for age-0 juvenile salmon to move from spawning to summer rearing locations, and for most age1+ Chinook Salmon to emigrate from the Middle River. Fish sampling must be conducted to provide a measure of relative abundance on each sampling date and at each sampling site.
d. Cold brand all Chinook and Coho Salmon captured on each sampling event with unique marks for sampling location, and individuals to determine average growth within a site between sampling events and individual growth for recaptured fish. Measure at the fork length of ll fish and the first 50 of each species at each sampling location and each sampling event should be weighed to the nearest 0.1 g (instead of to the nearest 1.0 g). Invertebrate drift sampling should occur every other week throughout this time period.
e. Coordinate this study with other studies to determine the number and locations of additional water temperature monitoring locations within each sampling site to provide accurate and representative values. This modification will be best accomplished within a new study for Model Integration. A New Study request for Model Integration is included as an enclosure.

Sampling locations for juvenile salmon and other target fish species were not representative of the macrohabitat sampled and did not provide replication. The study plan required sampling of four or five replicates of each macrohabitat type. This replication was particularly important for side sloughs, upland sloughs, and tributary mouth habitats that are likely more variable in drift and water temperature than main channel and side channels. The study was instead implemented at a total of only three sites AEA classified as upland sloughs. However, the site near Montana Creek was not an upland slough, and no Coho Salmon were captured at the upland slough in FA 141. Therefore the study only reflected Coho Salmon growth in the FA 104 upland slough. Similarly, only one side slough was sampled at FA 104, even though side slough habitat was present near Montana Creek (RM 81) and Indian River (FA 141). Any measures of Coho or Chinook Salmon growth or consumption rates of Coho or Chinook Salmon are only representative of a single side slough, and the side slough in FA 104 cannot be considered representative of Middle River side sloughs.

Statistical evaluation of differences in growth among macrohabitats are essentially testing for differences between the side slough and the upland slough in FA-104, without considering that inaccurate growth estimates result from analysis using such small sample sizes. Macroinvertebrate drift, water temperature, and fish sampling was not conducted in the two tributary mouths (Montana Creek and Indian River) but instead in tributary deltas which are not preferred habitat for juvenile salmon. Sampling of FA 104 tributary mouth/side slough (RP 104-1) did not occur in either of these habitats (tributary mouths discharging into side channels or main channels) but was conducted in a tributary. NMFS recommends that he study be repeated at five or more side slough, upland slough, tributary mouth, main channel and side channel habitats.

Growth was not measured from the change in length or weight of marked fish within each habitat as required in the approved study plan. AEA states that this was not conducted because this method could not track individual fish and it wasn't possible to determine if fish left the tagging site and reared in another location and then returned. This is not correct. Merz (2002) used subcutaneous dye marks to identify individual O. mykiss for as long as 985 days, tracking some movement and residency. The study was also able to estimate growth of individual fish. Not using subcutaneous dye marking affected success of meeting study objectives. As study variance, AEA proposed to determine growth from recaptured PIT tagged fish. NMFS does not agree with using this proposed study variance to meet the objective. because (1) only fish > 55 mm can be PIT tagged, (2) PIT tagged fish also could leave and return to a macrohabitat undetected (although NMFS believes this is unlikely), (3) PIT tagged fish for estimating growth for length at age (as proposed in the RSP) will provide measures for fish that may not represent the population, particularly as larger fish are selected for PIT tags, (4) cold branding can be applied to a larger number of fish at a much lower cost, and (5) combined locations and colors of tagging can be used to mark individual fish. To date, AEA has not recaptured enough PIT tagged fish to determine growth within each replicate macrohabitat.

Since juvenile salmon were not marked, it is not clear if growth occurred within the habitat under investigation. Ultimately, the change in the mean weight at age was used to estimate growth. Growth based on changes in the mean weight of target fish species of open populations did not account for any loss, recruitment, immigration, or emigration. Apparent growth, as a change in the mean weight can be due to the death of smaller juvenile fish. The death of smaller fish will result in an increase in mean weight but is not due to true growth. A reduction in relative abundance over time (truncation of the size frequency distribution) could indicate the loss of fish from the population. However, since abundance or relative abundance was not measured in each macrohabitat type, it is not clear whether the changes in length over time are due to growth, or the death of smaller fish. Similarly, immigration of larger fish or emigration of smaller fish would result in a change in the mean weight over time and would results in errors in growth measurements and all modelled parameters.

At a minimum, intensive fish sampling must be conducted to obtain measures of relative abundance to determine if change in the mode of the size distribution could be due to the death or emigration of smaller fish (reduced relative abundance) or the immigration or recruitment of fry (increase in relative abundance). AEA does not clearly specify the level of effort applied to fish sampling at productivity sites. In 2013, an unknown number of fish traps were set for 90 minutes. This level of fish sampling effort was insufficient. For juvenile Coho and Chinook Salmon, NFMS recommends the use of baited minnow traps fished for 20 to 24 hours at a density of one trap per every ten meters of shoreline. This would require 20 traps for all productivity sampling units in off-channel habitats.

NMFS does not agree with AEA's changes in target fish species. The study must evaluate the bioenergetics of juvenile Coho Salmon and Chinook Salmon. The FDA study demonstrated that juvenile Chinook and Coho Salmon are abundant in main- and off-channel habitats of the Middle River.

Sample sizes of Chinook Salmon in 2013 and 2014 were too small to accurately represent Middle River Chinook Salmon or macrohabitats. In 2013, a total of four age-0 Chinook Salmon were captured and aged, and only five during the fall (AEA Figure 5.4-2). These samples sizes do not allow for an accurate measure of weight at age for Chinook Salmon in 2013. This also means that accurate diet could not be determined to calculate the energy derived from different prey items used to model consumption and growth efficiency. In 2014, only 3 age-0 Chinook Salmon juveniles were captured during the summer from the single Middle River side slough habitat and none in spring or fall (AEA Table 4.7-1 through 3). During 2014, a total of 10 Chinook Salmon were sampled during summer and 13 during fall from the two Middle River tributary mouths. For upland sloughs, the total number Middle River juvenile Chinook Salmon sampled was 11 in summer and four in the fall. This means that spring to summer juvenile Chinook Salmon growth in side sloughs, which are common throughout the Middle River and provide important juvenile Chinook Salmon habitat (1980s study), is based on the length of only three fish from one side slough, and cannot be measured for the summer to fall time period. However, AEA Table 5.4-2 reports values for these habitats without recognizing these limitations.

Diet composition was variable among fish species at a given site, over time, and, based on diet and stable isotope mixing models, among sites and macrohabitat types. Water temperature was variable within a site, and among macrohabitats. However, as shown in Table 5.4-2, a single value is reported for modelled consumption and growth efficiency for pooled habitat types. Using a single value for growth but different values for water temperature and diet as study results documented, should result in different modelled values of consumption and growth efficiency for each site. If measured water temperature is different between side sloughs, upland sloughs, and tributary mouths, and diets differ among these habitats, but growth rates are the same, then it is not possible to have a single value for modelled consumption and growth efficiency that represents all three habitat types. In addition, maximum consumption rates (P_{max}) also varies with water temperature and would result in different values for growth efficiency among sampling sites. It may be that using site specific values of diet composition results in unrealistic consumption and growth efficiency values, which would strongly suggest errors in growth estimates. If the model was run using only values of temperature and diet from a single site or average values, then results are not representative of multiple different macrohabitat types and must not be reported as such.

Water temperature data and turbidity data reported by the River Productivity Study do not appear to be representative of the sampling sites. No quality assurance project plan was developed for water temperature or turbidity monitoring. As reported, water temperature loggers in some macrohabitats appear to have been placed in upwelling waters or buried in sediment. No details are provided in the study report on finding locations of representative well-mixed water temperatures for logger placement or seasonal maintenance of water temperature loggers. For some sampling sites multiple water temperature loggers may be necessary to document current conditions. Prior to the next year of study, AEA must develop a quality assurance project plan to describe the quality assurance and field methods that will be implemented to ensure that accurate and representative water temperature and turbidity data are collected.

Modification 5-2: In regards to the Growth Rate Potential Study, until a foraging model for age-0 Coho and Chinook Salmon becomes available and applicable for all water velocities, the effort directed toward this study should be shifted to obtain more accurate field measures of juvenile salmon growth and water temperatures within all macrohabitats.

Growth rate potential is growth rate modeled from field measures of drift density, water velocity, and water temperature by combining a foraging model and the bioenergetics model. The foraging model estimates consumption rates from drift density and water velocity for water velocities > 0.95 ft/s. Apparently, a foraging model has only been developed for age-1 Coho Salmon. The estimates of growth rate potential are not useful given the limitation to a single species and age class and for water velocities over 1 ft/s.

Expending additional energy to obtain field measures of growth rates must be applied in order to measure the current environment and predict project effects. If accurate growth rates are obtained from multiple replicate habitat types along with water temperature, water velocities, turbidity, and drift, then the model can be used to evaluate the relationship between water velocity, drift, turbidity and consumption.

Modification 5-3: The study must be modified to include four Middle River Focus Areas including Indian River (FA141), Gold Creek (FA 138), Skull Creek (FA-128), and Whiskers Creek (FA 104).

If only two focus areas are studied, which we do not recommend, they should be FA 128 and FA 104. This would provide some continuity with the 2013/2014 study, but a site should be added with Sockeye Salmon and Chum Salmon spawning and rearing populations of the target fish species (e.g., FA 128).

Modification 5-4: We request modification of the study so that that the requirement to sample 10 g of macroinvertebrates, and 5 g of algae, terrestrial invertebrates, benthic organic matter are obtained from a composite collected from 10 or more locations distributed systematically (20 m between sampling locations) or selected randomly within each macrohabitat within each focus area.

This modification is necessary to ensure that samples are representative of the macrohabitat under investigation.

NMFS (RSP comments , March 18, 2013) identified the lack of detail in IP regarding the focus areas, and locations within focus areas (specific macrohabitats), and number of salmon carcasses, algae, invertebrates, and target fish species that would be sampled at each sampling location as primary detail required to meet this objective. NFMS concern was that the Indian River focus area was near the upper extent of the spawning distribution of anadromous fish, and therefore, less likely to contain delta C ratios indicating marine nutrient sources. In addition, the Indian River FA supports most of the spawning salmon, and the tributary is at the downstream end of the focus area, therefore, sampling locations within the focus area upstream of the Indian River would be less likely to contain marine nutrients. Carbon and nitrogen uptake from decomposing salmon carcasses would occur primarily within Indian River, and downstream of Indian River in the main-stem Susitna River. Marine sources of carbon and nitrogen upstream from Indian River could only come from spawning locations upstream (Portage and Slough 21) or from fish migrating upstream out of Indian River in the Susitna River. NMFS recommended a number of additional potential sites within the Middle Susitna River that support salmon spawning and were more likely to contain the target fish species (Coho and Chinook Salmon, and Rainbow Trout). FERC required consultation with NMFS prior to selecting sampling locations. AEA did not consult with the Services and conducted the study in the Indian River Focus area. AEA added additional sampling locations, but the new sampling locations were not those recommended by NMFS.

NMFS does not agree with the implemented study modification of selecting focus areas and sites without consultation as required by FERC. NMFS agrees with AEA's study modification to increase the number of sampling locations, but does not agree with the locations selected by AEA. According to AEA, additional sampling locations were selected to represent a potential gradient of marine derived nutrients. One additional site was selected at FA 184, at the proposed dam site above Devils Canyon, and the second site at RP-81 in the Lower River segment. As stated previously, NMFS believes that Indian River (FA 141) already represents a site that would likely have low ratios of marine to terrestrial carbon in target fish species. The FA 184 site is upstream of most salmon spawning habitat, and was not expected to support enough juvenile Coho or Chinook Salmon to conduct meet study objectives. This was substantiated through the implementation of this study in 2013. FA 184 is not representative of any substantial portion of the Middle River. The Lower River Montana Creek site may contain higher or lower ratios of marine nutrients as it is influenced by inputs from the Talkeetna and Chulitna Rivers, which may either concentrate or dilute marine carbon and nitrogen exported from the Middle River. We request that FERC reconsider NMFS's RSP comments (March 18, 2013) on sampling locations, and consult with NMFS as required by FERC prior to conducting any additional sampling.

The IP states that samples would be collected from salmon carcasses, target fish species, aquatic insects, terrestrial insects, algae, benthic organic matter, and transported organic matter and analyzed for carbon and nitrogen isotopes. The ISR does not state the number of target fish species that were sampled or where they were collected or sampling locations and numbers of samples for any of the insects, algae, or organic matter. Only 260 samples were collected from a potential 1,920 in 2013. This sampling is inadequate to meet study objectives. The study report is also deficient as it does not state where salmon carcasses were obtained or what species samples were collected from.

AEA stated in the IP that if stable isotope sampling goals were not achieved, then a portion of the sampling effort would be reallocated in order to reach objective goals. AEA did not reach the sampling number goals in 2013 yet there is no description in the ISR or SIR of how sampling effort was or will be reallocated in order to achieve them in the next year of study.

Objective 7: *Characterize the invertebrate compositions in the diets of the representative fish species in relationship to their source (benthic or drift component).*

Modification 7-1: Diets from a minimum of 8 fish with food in their stomachs for each fish species and life stage be analyzed as provided for in the approved study plan.

AEA attempted fish sampling at every site however it was not always within one week of the benthic and drift samples as required in the approved plan. At some sites the River Productivity study deployed minnow traps for a maximum of 90 minutes in effort to collect target fish for stomach samples. This level of effort was and is insufficient. AEA reported very few fish captures at Focus Areas 173 and 184. The total effort resulted in only 260 total stomach samples collected in 2013 out of a potential of 1,920. ISR Table 4.9-2 shows that some macrohabitats were not sampled by either the FDA Study or the River Productivity study leaving many unacceptable data gaps for this objective.

The AEA (2014 Fish Diet Analyses Technical Memorandum) report does not demonstrate that 8 stomachs adequately represent diet composition for each species by site and sample period for the 2013 data. The literature cited does not support this either.

The diminishing number of stomachs as sample size increases from one to eight creates an artificial decrease in the potential to observe new taxa, most likely artificially creating an asymptote well before it would occur in an adequate sample size. This should be rectified before further analysis or data collection occurs.

We recommend that the AEA pool all sites to see if the same pattern occurs or if a plateau occurs beyond the 8 samples suggested in their report. We further recommend assessment of diet data collected in earlier studies to help determine adequate sample size for each species, site and sample period. The results for this study reported in the ISR indicate that the 2013 sample period does not adequately represent diets of target fish species and that the goals of the study were not met for that period.

Modification G-1: (Global) Expand the geographic scope of the River Productivity study to the entire Lower River.

The Lower Susitna River is defined as the approximate 102-mile section of river between the Three Rivers Confluence and Cook Inlet. The potential impacts to the biological productivity of the lower reach of the Susitna River from the construction and operation of the Susitna-Watana Hydroelectric Project need to be appropriately and accurately estimated. The functional roles that algae and macroinvertebrates play in food webs and energy flow ultimately affect the growth and productivity of various aquatic species seasonally occupying the Susitna River, Cook Inlet, and Pacific Ocean. Such species include all five ecologically, culturally, and economically valuable species of Pacific salmon as well as eulachon and Cook Inlet beluga whales. Understanding the expected changes in nutrients, algae, and invertebrates in the Lower Susitna would directly inform understanding of the secondary effects on fish distribution, run timing, and relative abundance if the proposed project is constructed and operated. This information is necessary for NMFS to develop measures that will protect, mitigate and possibly enhance fish and wildlife resources affected by Project construction and operations.

The existing nine River Productivity Study objectives must be geographically expanded to assess the full extent of changes that are likely to occur in the Lower River as a result of the proposed project. Methodology must be consistent with the modifications for the objectives described above and the additional biological information gathered in this study must be provided with an equivalent level of detail to the study of River Productivity in Middle and Upper reaches. AEA must consult with licensing participants to determine optimum sampling locations.

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9.9 Characterization and Mapping of Aquatic Habitats

ISR Review and Study Modifications

The National Marine Fisheries Service's (NMFS) evaluation of potential effects of the proposed Susitna-Watana hydroelectric project will largely depend upon identification of fish habitat relationships applying the Alaska Energy Authority's (AEA) hierarchical habitat classification model, and their ability to develop realistic flow-habitat relationships, pursuant to this model.. Clear, accurate, and repeatable classification of habitat, at all spatial scales, is essential to this evaluation. Throughout study plan development and at technical working group meetings (TWGs), NMFS stressed the requirement of accurate and complete habitat classification as a basis for describing baseline conditions and estimating project effects to AEA and the Federal Energy Regulatory Commission (FERC).

AEA's Revised Study Plan (RSP) (December 2012), as modified by the FERC Study Plan Determination (SPD) (April 1, 2013), established a habitat model that was to be used to classify and quantify habitat in the Susitna River and its tributaries. This model was also to serve the basis to stratify surveys of the distribution and abundance of fish, river productivity, and microhabitat utilization and availability.

Study Objectives

The objectives of the study, as provided in the FERC SPD (April 1, 2013), are summarized here as follows:

- **Objectives 1 and 2:** Characterize and map Upper River tributaries and lake habitats to evaluate the loss or gain in fluvial habitat and to inform other studies.
- **Objectives 3 and 4:** Characterize and map the Upper River mainstem to evaluate the loss or gain in fluvial habitat and to inform other studies (3); Characterize and map the Middle River mainstem to evaluate the loss or gain in fluvial habitat and to inform other studies (4).
- **Objective 5:** Characterize and map the Lower River mainstem to evaluate the loss or gain in fluvial habitat and to inform other studies.

NMFS has attended and participated in numerous technical working group (TWG) meetings and Instream Flow (ISF) technical team meetings (TTM), and has provided detailed Interim and RSP comments to FERC with the intent to ensure that Susitna River habitats were consistently and accurately classified, and that the results were presented in a format that could be used by AEA, FERC, and other review participants. Though various media were available (LiDAR, aerial photos, and video) were available to AEA in 2012, NMFS is concerned that AEA's first "final" habitat maps were released in the Initial Study Report (ISR) (June 2014), and again with the Study Completion Report (SCR) (October 2015). This was long after the Focus Areas (FA) were selected, and fish distribution and abundance, river productivity, and microhabitat utilization and availability surveys were performed.

NMFS reviewed the ISR (June 2014) and SCR (October 2015) reports, attachments, and errata submitted by AEA and found that the field data collection for Upper River tributaries was conducted as proposed within the RSP. However, data analyses and data results were not presented as proposed in the study plan. It is therefore unlikely that independent reviews can be made to determine if the study implemented in the Upper River tributaries will meet project objectives. Additionally, AEA did not provide geomorphic classification of the approximately 69 Middle River tributaries within the ISR, as required per the study plan.

NMFS comparisons of AEA's habitat classification, based on 2012 aerial imagery and 2013 AEA field surveys, revealed numerous discrepancies at the macrohabitat level. The percent difference between macrohabitat (Level 3) classification shown in line maps and macrohabitat classification from field surveys averaged 43%, and ranged from 0%, for the single multiple split channel to 57.9% for upland sloughs. AEA's ability to survey and assess fish habitat relationships, with sufficient accuracy, depends upon consistent, accurate habitat classification which appears lacking.

NMFS reviewed AEA's 2012 aerial imagery and determined that AEA's habitat classification in the SCR (October 2015, Appendix A and B) is largely inaccurate, inconsistent, and incomplete. To summarize these problems:

- Some tributary mouths were identified by AEA on the line maps and others were not; AEA line maps identified 34 Middle River tributary mouths, while NMFS identified 69, using AEA's hierarchical habitat model.
- The line mapping identified some clear water plumes but other clear water plumes were not identified on the final maps (12 shown on AEA ISR line maps compared to the 69 NMFS counted).
- The upland slough classification was incorrectly applied to tributaries and disconnected oxbow lakes; upland sloughs were misclassified as side sloughs, and side sloughs were often misclassified as side channels. These macrohabitats consistently display significant physical habitat characteristics and patterns of fish habitat utilization.
- Ephemeral cross-island (flood) channels were classified as separate macrohabitats that did not comply with the study definitions.

Inconsistent and inaccurate classification has resulted in errors in fish distribution and abundance and productivity sampling location selections. Microhabitat utilization and availability were surveyed with no regard to the Project hierarchical habitat model. This degree of error and departure from the FERC determination will prevent AEA from developing and predicting realistic and accurate flow-habitat relationships.

Our general observations of the ISR 9.9 Characterization and Mapping of Aquatic Habitats are:

1. Study results were presented in numerous documents that were not clearly linked to one another,

2. Middle and Upper River macrohabitat mapping was incomplete with conflicting classifications amongst documents and those within tables,
3. Results and analyses in Upper River Technical Memoranda mix classification levels and do not follow the approved Level 3 and Level 4 habitat classification,
4. Ground-surveyed subsamples were presented as representative of the entire tributary or mainstem from which the subsample was taken. Given the survey protocol, this was unrealistic
5. Results from ground surveys were not used to resolve line mapping errors,
6. Geomorphic classification of Middle River tributaries was not provided,
7. In comparison to aerial line surveys, initial ground surveys underestimated off-channel level 4 habitats,
8. Off-channel mesohabitat mapping, including measures of woody debris, undercut banks, etc. has not been completed, and
9. Study results were not presented in a manner that clearly describes the length, and/or area of each level within the hierarchical habitat model.

Given these errors, study results do not currently meet the study objectives. As the basis for all other studies, this study must be accurately completed prior to any additional sampling. Therefore, NMFS is recommending that AEA complete the habitat classification, according to their hierarchical habitat model and present the study results as outlined in the approved sampling plan. If necessary, a technical team, with agency support, should be developed to accurately and consistently complete the habitat classification as outlined in the approved plan.

NMFS Study Modifications

1. Provide a single Upper River habitat classification in a single document (Objectives 1 and 2).
2. Produce tables summarizing the coordinates and slope of each tributary reach, with the confinement, width, substrate, and other characteristics of the channel. (Objectives 1 and 2).
3. Present the relative distribution of habitats below the inundation zone, and the classification of habitats within the varial zone and above maximum pool elevation. (Objectives 1 and 2).
4. Provide the geomorphic classification for all Middle River tributaries per the FERC study determination (Objectives 1 and 2).
5. Review the aerial video for the Middle and Upper River and accurately and consistently classify the Level 3 macrohabitats and Level 4 mesohabitats for the main channel and visible off-channel habitats (Objectives 3 and 4).
6. Correct misclassification of ephemeral bar and island dissection (flood) channels as side channels, side sloughs, or upland sloughs. Also prevent the use of flood channels to address study objectives (Objectives 3 and 4). These flood channels are ephemeral because they have not been incised to a depth in which they interact with the water table.
7. Clearly define and accurately apply the mesohabitat classification to Susitna River habitats (Objectives 3 and 4).

8. Provide results of the mainstem classification in tables showing lengths of each line on line maps for all Susitna River macrohabitats (main channel and off-channel), as provided for in the approved plan (Objectives 3 and 4).
9. Provide maps and tables showing Upper River and Middle River macrohabitat area as proposed in the FERC-approved plan (Objectives 3 and 4).
10. For both the Upper and Middle Rivers: complete ground surveys of 5 to 10 mainstem and off-channel mesohabitats, classify mesohabitats in off-channels, and provide Tier III habitat characteristics. AEA should also complete the 100% survey and classification of mesohabitats for all macrohabitats in FAs, including the percentage composition of mesohabitats within and for each macrohabitat (Objectives 3 and 4). As implemented, AEA did not use mesohabitat classifications to structure surveys of microhabitat or fish distribution data. The forfeited the intent of using habitat mapping to collected representative data and make valid comparisons.
11. Show beaver pond complexes and backwater mesohabitats on classification maps for the entire Middle River (Objectives 3 and 4). These are physically unique habitats supporting unique patterns of fish habitat utilization.
12. Expand the geographic scope of this study from the Yentna confluence to the Cook Inlet.

Review by Objective

Objective 1 and 2: *Characterize and map Upper River tributaries and lake habitats to evaluate the loss or gain in fluvial habitat and to inform other studies.*

Modification 1: NMFS recommends that the Upper River habitat classification be provided in a single document. This recommendation is necessary to ensure that all information provided is current and includes any study modifications or additional analyses recommended through TWG meetings or by FERC.

The ISR (June 2014) or SCR (October 2015) does not contain Upper River tributary classification results, but refers to other technical memoranda or appendices to other study plans. These technical memoranda were completed prior to study plan approval. Since the classification of Upper River tributaries was largely completed in 2012, AEA should have completed an ISR or SCR that contained all of the Upper River study results within a single document and with incorporated changes in habitat classification levels, as described in the FERC SPD (April 1, 2013).

Modification 2: Study results should be provided in a table for each Upper River tributary that show the starting elevation and ending elevation of each geomorphic reach, reach slope, confinement, channel width, substrate, and other habitat variables. Information on each geomorphic reach will provide NMFS with the ability to determine if habitat and fish distributions are similar among geomorphic reaches, with the same physical characteristics within a stream and among streams.

Reach characteristics are needed to determine the total number and locations of reaches with distinct morphological differences. That is, does each tributary contain three distinct geomorphic reaches, common among all Upper River tributaries, or do some tributaries have unique geomorphic reaches

Modification 3: Study results for Upper River tributaries should be presented to show the relative distribution of habitats below the inundation zone, and classified habitats within the varial zone and above maximum pool elevation.

NMFS recommends that the Upper River tributary classification include tributary habitats at all classification levels that will be directly altered by the proposed project. This request was made by NMFS during TWG meetings. It is important to understand the geomorphic reaches and tributary mesohabitats that will be lost due to their location within the inundation and varial zone, and to be able to compare this with tributary habitats projected to be above maximum pool elevation, under all operational scenarios. These results, along with fish habitat associations for each tributary from Study 9.5, will be used to estimate project effects to the fish community, assuming ecologically relevant fish habitat models will be constructed.

Modification 4: NMFS recommends that AEA provide the geomorphic classification for all Middle River tributaries, as provided for in the FERC study plan determination (April 1, 2013).

AEA did not incorporate recommendations from the FERC determination. FERC stated, "We recommend modifying the study plan to have AEA classify Middle River tributary reaches within the zone of hydrologic influence into geomorphic reaches based on tributary basin drainage area and stream gradient to provide a general understanding of the relative potential value to fish and aquatic resources, and report on these attributes in the initial and updated study reports."

AEA did not provide a geomorphic classification for Middle River tributaries within Study 9.9 ISR (June 2014) or SCR (October 2015). This information is necessary to determine if all tributaries and tributary mouths support the same fish community or if the fish community varies by the tributary geomorphic classification (e.g. low sloped wetland stream, lake-stream complexes, or moderate sloped streams). Tributary classification will be used to determine if fish distribution and productivity sampling adequately represented tributary mouth types present within the Middle River.

Objectives 3 and 4 (rephrased for greater specificity): *Characterize and map the Upper River mainstem from the proposed Watana dam site to the Oshetna River to evaluate the loss or gain in fluvial habitat and to inform other studies; Characterize and map the Middle River to evaluate the gain or loss in fluvial habitat and to inform other studies.*

Modification 5: NMFS recommends that FERC require AEA to review the aerial videography for the Middle and Upper River and accurately and consistently classify the Level 3 macrohabitats and Level 4 mesohabitats for the main channel and visible off-channel habitats, using the classification definitions or criteria provided for in the SPD (April 1, 2013). Ground surveys need to be conducted at survey flows to classify those macrohabitats that cannot be definitively identified from aerial videography.

Detailed habitat mapping of the Susitna River, according to AEA's hierarchical habitat model, is an essential foundation to the environmental assessment of this project. The hierarchical habitat model was to structure surveys of all data and their analysis. Though the NMFS put forward extensive efforts to work with AEA and FERC, we find the study results presented in ISR (June 2014) and SCR (October 2015) for Study 9.9 to be inaccurate and incomplete. This may prevent AEA from meeting their study objectives.

AEA developed a habitat mapping strategy that would use aerial video (September 2012), LiDAR, and aerial photographs to classify Level 3 macrohabitats and Level 4 mesohabitats for main and side channels and visible off channel habitats. The classification was to be conducted to inform other studies and to document existing conditions. The RSP (December 2012) described ground-truthing as a method to verify habitat classification from aerial imagery, to conduct mesohabitat classifications in FAs, and to provide Tier III survey data. Ground-truthing was to be conducted at flows similar to those when aerial imagery was obtained, but it was not. AEA also did not implement the classification put forth in the SPD.

AEA also used ground surveys to modify macrohabitat classifications that were specified in the SPD. In recent ISR meetings, AEA stated that 6 macrohabitat classifications were changed following ground-truthing. It is important to note that this did not simply mean there were only six locations where the classification from ground-truthing was different from the classification from aerial imagery. Next, the RSP (December 2012) and SCR (October 2015) do not provide a protocol for modifying classifications when there are differences between aerial imagery and ground-truthing results. The discrepancies are meaningful and should not simply be edited away. The habitat classification should only have been modified if systematic errors; that could have been applied to the entire Middle and Upper River, were identified. With these points in mind, we draw attention to AEA's altered classification of a side channel in FA 104 to a side slough and a side channel in FA 113 to a side slough based on ground-truthing results. The following questions illustrate the uncertainty concerning the results of this study.

1. How many other side channels or side sloughs, which were not ground-truthed, were also classified incorrectly from aerial imagery?
2. If errors resulted in reclassification, why wasn't the classification changed for other side channels or side sloughs not ground surveyed?

The mouth of Whiskers Creek in FA 104 provides a good example of the inconsistency in habitat classification and the efficacy of the results in meeting project objectives. The habitat classification maps released in November of 2014 (after the first study year) (ISR Attachment L 2014) identified the mouth of Whiskers Creek as a side slough, with no backwater or clearwater plume mesohabitat (Figure 1). The 2013 ground survey classified the mouth of Whiskers Creek as a main channel pool with a main channel clear water plume (ISR Appendix D). The most recent maps provided with the SCR in 2015 (SCR Appendix B) classify this habitat as a side slough with backwater mesohabitat and a side channel clearwater plume. Furthermore, this most recent classification cannot be used to retroactively inform early surveys that that were structured around the earlier classifications. It is also important to note that this confusion was within a FA where the most detailed studies are to be conducted. As a result, the River Productivity study inconsistently referred to samples collected at this location as both tributary mouth and side slough (see Study 9.8 SCR).

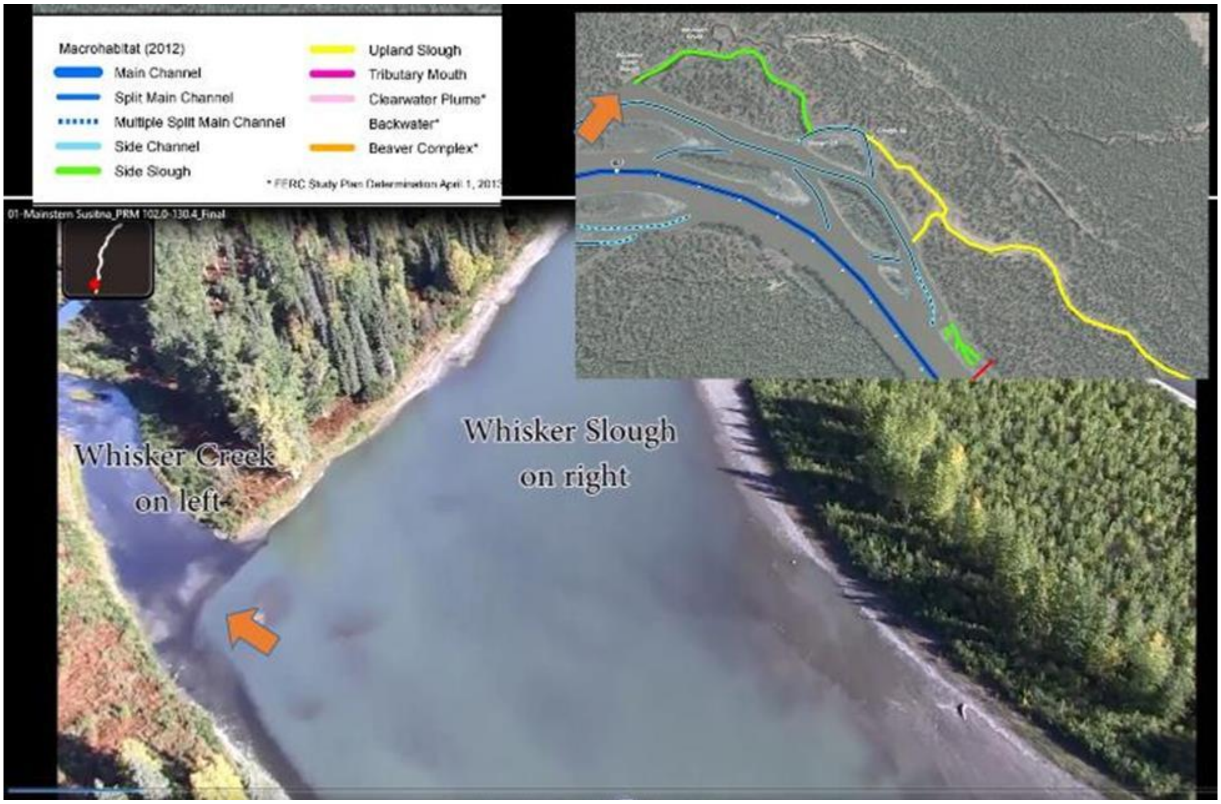

Figure 1. Screen capture of AEA 2012 video, inset of AEA remote line map classification, and classification legend showing Whiskers Creek tributary mouth within FA-104 misclassified by AEA as a side slough. Site should be classified as a tributary mouth with backwater and clearwater plume mesohabitats

The confusion noted in the Whiskers Creek example could be due, in part, to two main factors. At the macrohabitat level (Level 3), AEA did not update their study methodology to clarify how to classify habitats where two different classifications merge (i.e. slough and tributary). AEA also did not provide a method to differentiate between pools and backwaters at the mouths of side channels, sloughs, or tributaries at the mesohabitat level (Level 4). NMFS has always identified the habitat downstream of the confluence of Whiskers Creek as a tributary mouth (due to the dominance of flow from Whiskers Creek) that contains backwater and a clearwater plume (Figure 2).

Figure 2. Aerial photograph of the mouth of Whiskers Creek showing the confluence with the side slough and mainstem Susitna River and the dominance of tributary habitat downstream from the side slough confluence.

Due to the large differences between AEA's final classification and ground surveys, NMFS reviewed AEA's aerial imagery to see why these differences occurred. To perform this inquiry, we used AEA's classifications to develop a dichotomous macrohabitat classification key (Appendix A). A systematic, repeatable approach is essential to performing valid and useful habitat classifications. Using this dichotomous key, we compared the surveyed macrohabitat classifications for the Middle River (ISR Appendix D, June 2014) with final macrohabitat classification in revised Appendix A (ISR Appendix L, June 2014).

The results of our NMFS comparison of consistency between AEA's macrohabitat classification from aerial imagery and ground surveys are summarized in Table 1 and Appendix B. Of the 95 macrohabitats identified, 41 (43.2%) were classified differently by ground surveys (ISR Appendix D) compared to the final line maps (ISR revised Appendix A or L. There were 10 channels classified by ground surveys that were unclassified on the aerial videography; therefore, an estimated 10% of the Middle and Upper River macrohabitats are unclassified. Differences in habitat classifications ranged from 17% for main channels to 58% for upland sloughs. NMFS review identified numerous errors in the AEA line map classification including inaccuracies, inconsistency, and incompleteness.

	Total	Different	% Different
All Macrohabitats	95	41	43.2
Main Channel	17	3	17.6
Multiple Split	1	0	0.0
Side Channel	34	10	29.4
Split Main	18	3	16.7
Side Slough	13	4	30.8
Upland Slough	19	11	57.9
Unclassified	10	10	100.0

Table 1. Total number of Middle River habitats classified by ground surveys (ISR Appendix D), the number of macrohabitat classifications that were different than those shown on AEA final line maps (ISR Appendix L), and the percent difference (Different/Total x 100).

Tributary Mouths

Tributary mouths are defined by AEA as "clearwater areas that exist where tributaries flow into the main channel or side channels." This definition includes both the tributary delta or backwater, and the clearwater plume caused by tributary discharge. One objective of habitat characterization is to inform other studies (e.g. Fish Distribution and Abundance study 9.6). The FERC determination for study 9.5 recommended that tributary mouth macrohabitat sampling extend 200 m downstream from where tributaries enter the main channel or side channel. Therefore, the habitat characterization study should have identified all tributary mouth macrohabitats as tributaries that contain a clearwater plume mesohabitat. However, tributary mouths were consistently misclassified.

For example, Chase Creek (SCR October 2015, Appendix A Map 51) is shown with a clearwater plume as main channel mesohabitat but not as a tributary mouth macrohabitat. This resulted from failure to define habitats in accordance with the approved study plan. If clearwater plumes are a mesohabitat of tributary mouths, then only those tributary mouths with clearwater plumes need to be classified. If clearwater plumes are a mesohabitat of main channels or side channels, then all 69 Middle River tributaries flowing into the Susitna River need to be identified as tributary mouths.

In the SCR (October 2015), Appendix A Map 50 in FA 113, the tributary 113.7 has a classified tributary mouth. Nearby Slash Creek and Gash Creek, however, are not identified as tributary mouths, even though clearwater plumes are visible at the mouths of both of these streams. Tributary 115.4 (Map 50 of 55) in FA 115 is identified as a tributary mouth with no clearwater plume mesohabitat. Lane Creek has a main channel clearwater plume mesohabitat and is identified as a tributary mouth (Map 49 of 55); however, the clearwater plume and tributary mouth at unnamed tributary 117.4 were not classified, even though a plume is clearly visible on the aerial imagery (Figure 3). McKenzie Creek and Little Portage Creek are not tributary mouths according to AEA (Map 47 of 55). However, they are both clearly tributaries and tributary plumes are visible on aerial imagery (Figure 4). The tributary at 124.4 (Curry) is identified as a tributary mouth (SCR October 2015, Map 46 of 50) but the tributary clearwater plume is not classified, though clearly visible (Figure 5). If a tributary clearwater plume is not necessary for tributary mouth classification, then it is not clear why this is a tributary mouth while other tributary confluences were not classified. These same errors and inconsistencies continue throughout the river. Therefore it is not possible for the results of this classification, as shown in the SCR, to inform other studies on the number of tributary mouths available for sampling.

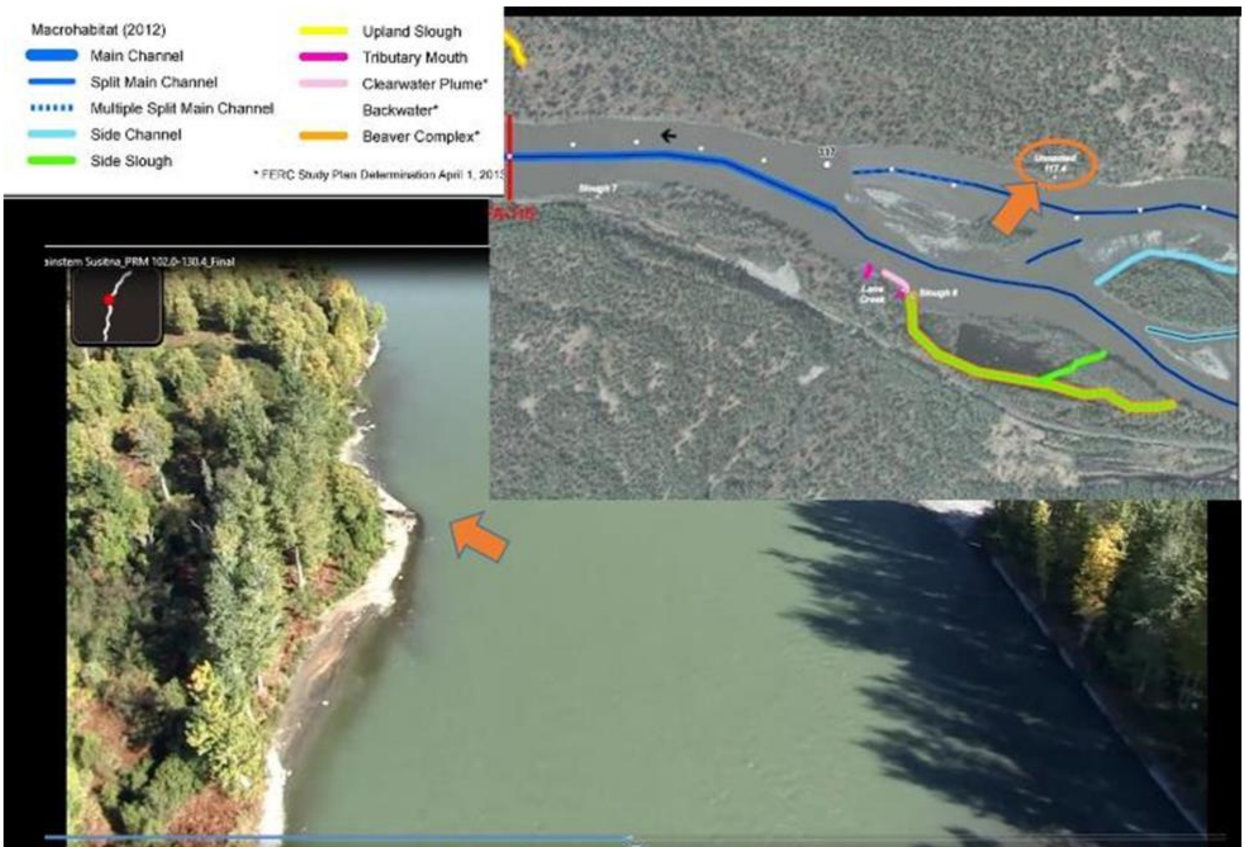

Figure 3. Tributary 117.4 (arrows) as an example of habitat not classified by AEA as tributary mouth macrohabitat and clearwater plume; however, the habitat is clearly visible in the AEA's 2012 imagery used for the remote line mapping as shown on inset.

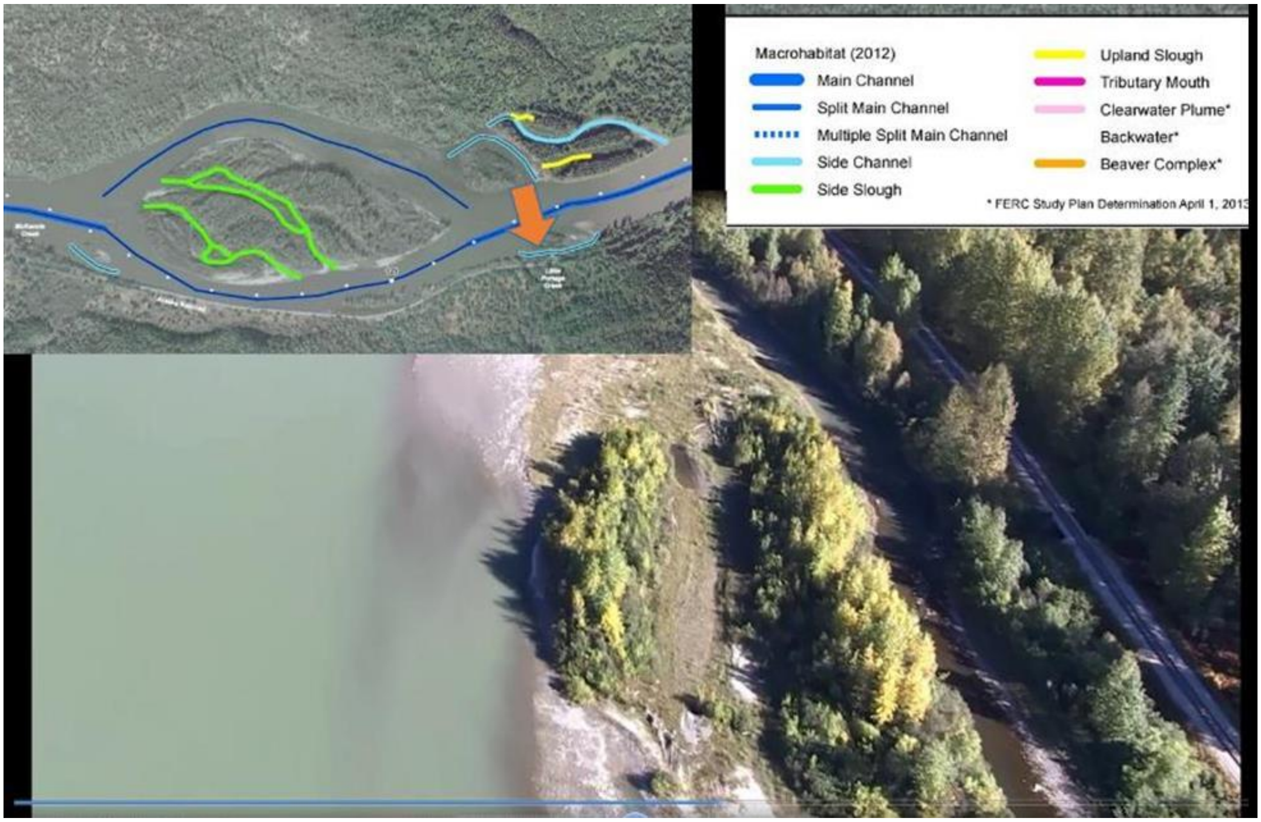

Figure 4. Little Portage Creek tributary mouth and clearwater plume not classified by AEA where it discharges into the Susitna River. Misclassified side channel as island length is < channel width.

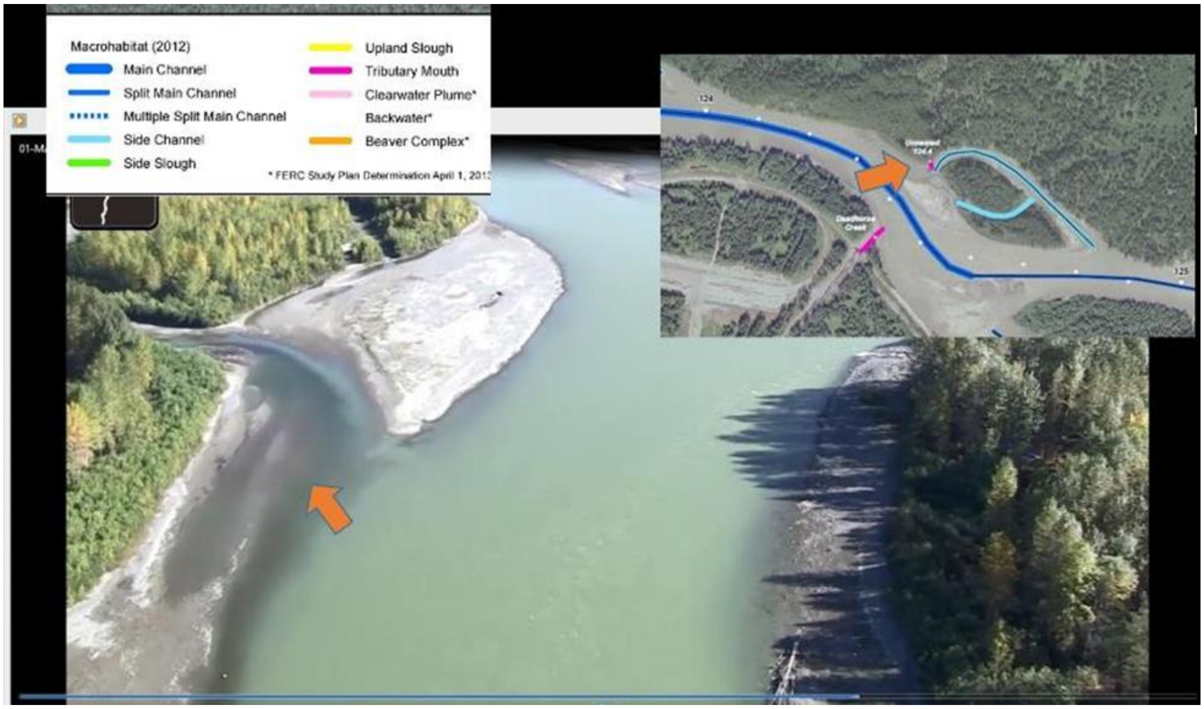

Figure 5. Tributary mouth classified by AEA (inset); however, obvious clearwater plume was not classified, although tributary plumes have been classified at other locations. AEA used clearwater plumes as one of the habitats for fish distribution and abundance sampling. Many tributary plumes were not classified and therefore, were not available for site selection. The importance of these habitats to the Middle River will be underestimated if not accurately and consistently classified.

The RSP clearly defines tributary mouths as locations where tributaries discharge into the main channel or side channel of the Susitna River, creating a downstream clearwater plume. NMFS recommends that AEA revisit the aerial imagery and accurately and consistently classify these Middle River tributary mouth macro and mesohabitats. Accurate and consistent habitat classifications should have been used to structure other surveys and will certainly be necessary prior to any additional field sampling.

Side Channels and Split Main Channels

Departure from the classification criteria led to inconsistent classification of side and split main channels. AEA classified side channels as those connected to the main channel but containing much less flow (~10%). Split channels were defined as bifurcations where a dominant or subdominant channel could not be readily identified. This left it inevitable that a large number of channels, those receiving greater than ~10% of the flow to remain unclassified. AEA further defined side channels as a channel separated from the main channel by an island whose length is greater than or equal to channel width and split channels as being separated by islands without permanent vegetation (permanent vegetation is not defined but is presumed to mean woody vegetation).

Evaluation of side and split channel classification in the FAs illustrates several issues with AEA's classification. In FA 104 the right channel was classified as a side channel (SCR October 2015, Appendix A Map 54 of 55). The channel is subdominant and may contain approximately 10% or more of total flow. The channel is separated from the main channel by an island with a length > channel width (if the cross-island channels are ignored). However, In FA 115 the left channel (flowing in front of Slash and Gash Creek, Map 50 of 55) is classified as a split main channel. This is inconsistent as this channel is also subdominant (not navigable under most flows), and is separated from the main channel by a long island. In addition, the island is clearly vegetated. Split channel classification is applied to one channel and side channel classification to another; however, both channels meet the classification description for side channel. This is an example of where AEA's classification was not accurately or consistently applied in areas where distinct physical characteristics have been identified. In addition, the cross-island channels in FA 115 are classified as split channels when they are clearly subdominant, whereas the cross-island channels if FA 104 are classified as side channels.

Such examples of misclassification are found throughout SCR Appendix A (October 2015); where the split main channel classification was applied to side channels. Additional examples include:

- Compare the split main channel classification of the channel at project river mile (PRM)125.5 (Map 45 of 55), which is clearly a subdominant channel on aerial imagery (Figure 6), with the side channel classification in FA 128 (Map 44 of 45). Both of these channels are subdominant, and likely contain ~10% of total flows, but one is classified as a split main channel and the other a side channel.
- The channel flowing past Slough 11 in FA 138 (Map 40 of 45) is clearly a subdominant channel, and is separated from the main channel by a vegetated island, but is miss-classified as a split main channel. This is inconsistent with the definitions in the approved plan.
- There is no clear basis for the two channels at the top of Map 38 of 55 in FA 138 to be classified as split main channels instead of side channels. The channels are clearly subdominant, contain roughly <10% of the flow, and are separated by long vegetated islands, whereas the small cross-island channel, which has been classified as a side channel, does not comply with the side channel classification.
- An exposed gravel bar in FA 173 (Map 26 of 55), at PRM 174 is classified as side channel, but does not comply with the classification descriptions. These types of inconsistencies and inaccuracies are found throughout the SCR (October 2015).

Figure 6. FA 128 Channel misclassified by AEA as a split main channel (inset). However aerial view in inset and video of the upstream end clearly shows that the channel is subdominant and therefore was misclassified by AEA. Channel should be classified as a side channel.

Side Channels and Side Sloughs

The side channel classification was also inaccurately and inconsistently applied to side sloughs. Side channels were to be differentiated from side sloughs based on the upstream connection to the main channel and water turbidity. This classification is flow dependent, since at high flows side sloughs can become connected to the main channel and can be dominated with turbid water. Flows of 10,000 to 12,000 cfs were defined to be used for classification.

Side channel habitat in FA 104 (Slough 3b) and FA 113 (Oxbow I) was changed to side slough habitat (ISR Appendix L, 2014 and SCR Appendix A Maps 54 and 50 of 55, 2015) in the most recent maps (SCR Appendix A, 2015). Therefore, the upstream connection and water clarity at these two sites shown on aerial imagery can be used to compare to other side channel sites to see if they also should be side channel or side slough habitat. The connectivity and clarity of Slough 3b and Oxbow I from aerial videography were shown in Figure 7 and 8. In this videography, the upstream ends of both sloughs are not overtopped and the water appears clear. Since the channels at PRM 119 (SCR Appendix A Map 45, 2015) are not overtopped and the water appears clear on videography (Figure 9), these sites also should be classified as side sloughs; however, they are classified by AEA as side channels. The channel in FA 128 (Slough 8A) is classified as a side channel; however, the upstream end is not overtopped on the videography and the water appears clear (Figure 10). It is unclear why channels in FA 104 and FA 113 are classified as side sloughs and the channel in FA 128 is classified as a side channel when they appear exactly the same on the 2012 aerial videography.

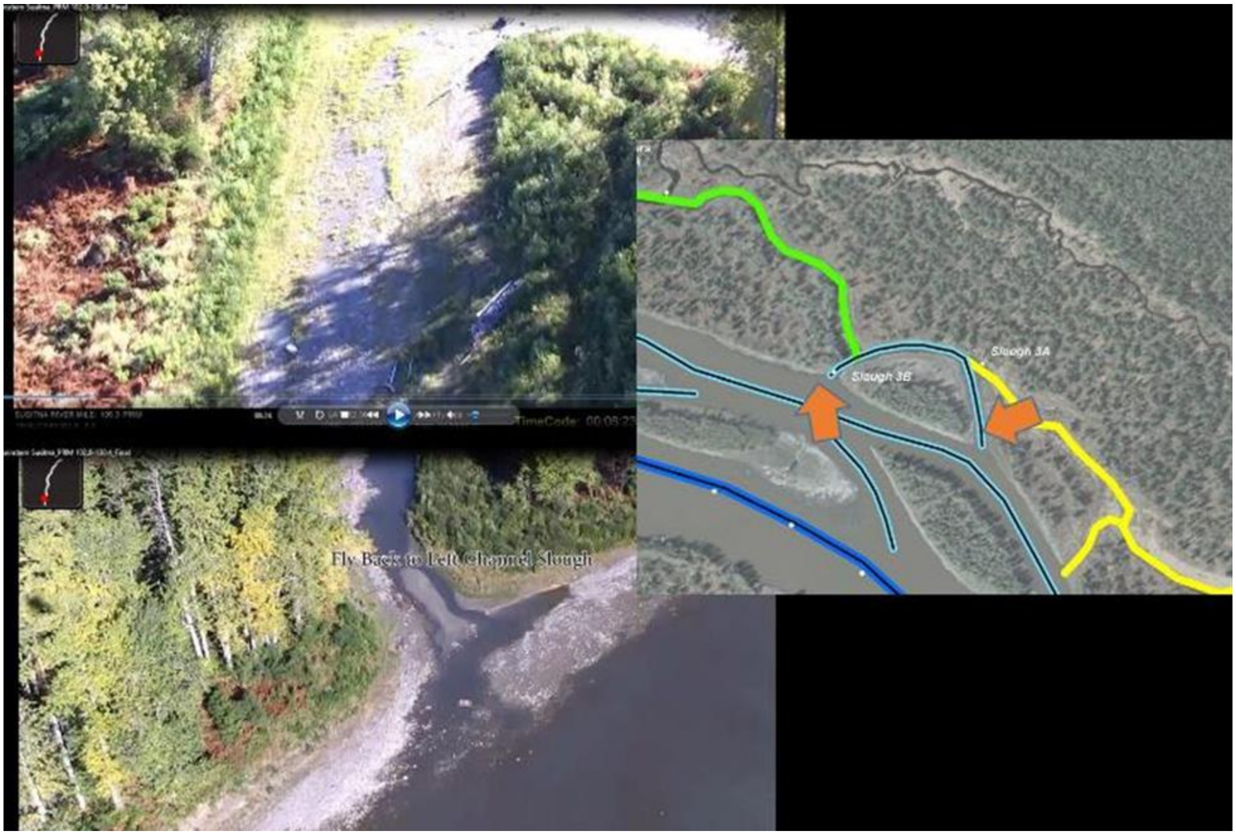

Figure 7. Upstream (top) (location shown with arrow on inset) and downstream (bottom) ends of channel within FA 104 from AEA 2012 video. Habitat was originally misclassified by AEA as side channel. The upstream end of the channel is partially vegetated and not connected to the mainstem and therefore, per AEA classification methods, the channel should be classified as a side slough. This channel was reclassified as side slough in AEAs latest classification maps.

Figure 8. Upstream and downstream ends of Oxbow I in FA 113. This channel was originally classified by AEA as side channel (inset) but was changed to a side slough in the SCR.

Figure 9. Two channels misclassified by AEA as side channels (inset). The right channel has clear water (bottom video capture) and upstream ends of both channels do not have an open water connection to the mainstem (top video capture). Based on AEA's classification methods both of these channels should be side sloughs. Side sloughs cannot change into split main channel as shown in inset.

Figure 10. Channel if FA 128 classified as a side channel. However, the conditions at the upstream end of the channel and clear water are the same as the chanels in FA 104 and FA 113 which were classified as side sloughs. Characteristics are consistent with side slough and not side channel classification.

Another example is the side slough complex near at PRM 131 (Figure 11) that was incorrectly classified as a network of side channels. Based on the approved classifications and classification of sites where AEA changed the classification from side channel to side sloughs in FA 104 and FA 113, these sites also should have been classified as side sloughs.

Figure 11. Differences in water turbidity and upstream connection to the main channel even under the higher flows in this aerial photograph shows that these side sloughs at PRM 131 were misclassified by AEA as side channels (inset).

The habitats downstream from where two different macrohabitats join, was also inconsistently classified. For example, in FA 173, side channel habitat merges with side slough habitat and the habitat downstream continues as side slough. However, if the side channel habitat classification is based on an upstream connection within the main channel, then the entire habitat downstream must also be connected to the main channel at the upstream end, even after it combines with another habitat type. Whenever a side slough and side channel combine, based on the classification, it must continue downstream as a side channel. Habitat downstream from the confluence of a side slough and an upland slough must continue as a side slough, not as upland slough (Slough 1 Map 55). Whiskers Creek intersects with a side slough and downstream habitat is classified as a side slough, but Chase Creek intersects with an upland slough and downstream habitat is classified as a tributary. Downstream habitat in both situations is dominated by tributary flow.

Figure 12. Cross-island channel in Focus Area 141 classified by AEA as a side channel and selected by the river productivity study as a sampling location representative of this macrohabitat type. Channel does not comply with the side channel definitions.

One objective of the habitat characterization study is to consistently survey and measure changes in fluvial habitat. Our habitat classifications, using the same methods and videography resulted in large differences in classification. Therefore, the "final" classification maps (SCR Appendix A, 2015) will not meet the study objective. The second study objective was to inform other studies. Studies 9.5, 9.6, and 9.8 selected sampling units based on macrohabitat classification, however many habitats that should have been available for site selection were never classified. For example, the Winter Fish study sampled upland slough habitat, in the most studied FA on the Middle River (FA 128), but the upland slough is not shown on the classification maps (Slough A on Map 44 of 45 below Skull Creek). We also know that many sites sampled were misclassified. Therefore, the study did not meet the second objective and has led to errors in the Fish Distribution and Abundance (FDA) and river productivity studies.

NMFS believes that most classification errors were due to inconsistent implementation of study methodology. Clear review of the aerial videography and consistent application of AEA's hierarchical classification model should eliminate most errors. NMFS recommends that AEA reclassify all Middle and Upper River macrohabitats according to their hierarchical habitat model criteria, using the aerial imagery. Site visits must be conducted, under survey flow conditions, to determine classification accuracy when locations are not clearly visible in aerial imagery. Licensing participants should be given an opportunity to review and comment on revised maps and final classification approved by FERC prior to any additional field sampling for FDA or river productivity.

Modification 6: NMFS recommends that ephemeral flood channels (cross-island channels) not be classified as side channels, side sloughs, or upland sloughs. They should also not be used to address study objectives. These channels should have a distinct classification for FDA and River Productivity sampling or not be sampled.

AEA's final line maps classify ephemeral bar-dissection (flood) channels as side channels, side sloughs, or upland sloughs, however short they are. These channels do not fit these defined habitats. For example, side channels, as defined by AEA, are connected to the mainstem with turbid water but carry a minor portion of the flow. They are also separated from the main channel by a vegetated island that is at least as large as the bank-full channel width. However, most of the islands created by flood channels do not meet this definition. Not only do these channels not meet AEA's classification, they arguably do not provide the same quantity and quality of fish habitat as similarly classified channels occupying the margins of the floodplain.

Juvenile salmon that are oriented toward the banks of large rivers are less likely to be found in cross-island channels. Juvenile salmon migrating downstream along the left or right river bank will enter the upstream or downstream ends of side channels and sloughs located on the river margins but will not encounter islands in the middle of the Susitna River unless they cross the main channel. Even if juveniles do encounter flood channels, the channel gradients are to too high to support rearing (the current is too swift to hold fish). The absence or low abundance of juvenile salmon in cross-island channels was documented in AEAs winter fish technical memorandum (see NMFS RSP Study 9.6 comments, March 18, 2013). The distribution of juvenile salmon will also influence the distribution and abundance of piscivorous resident fish. Therefore, these habitats are of limited value as habitat.

Due to these differences in physical characteristics and fish utilization, NMFS recommends that side slough, upland sough, and side channel classification not apply to cross-island flood channels and that these channels are not selected for FDA or river productivity sampling.

Modification 7: NMFS recommends that AEA clearly define and accurately apply mesohabitat classifications to Susitna River habitats. If selection of FDA surveys, summaries, and analyses are to be conducted at the mesohabitat level, then AEAs mesohabitat classification must be completed for all main and off-channel habitats in the Middle and Upper segments of the Susitna River.

Main channel and off-channel mesohabitats were not accurately and consistently classified. Specifically, remote line maps do not accurately classify or differentiate between runs, glides, or backwaters. Main channel habitats are classified as run/glide; however, these are two different habitat classification types (AEA Table 1.1-1). According to AEA's classification definitions, glides have slopes of 0 to 1% and therefore, will be most abundant in Susitna River mainstem channels. Runs have water surface slopes from 0.5 to 2% and are less likely to occur within Susitna River main or off-channels. AEA Table 5.1-14 differentiates glides from runs, but all slopes for both mesohabitats are less than 1and the table does not identify in which macrohabitat these mesohabitats occurred. Backwaters are areas where the water surface slope is 0% and are located where channels are governed by hydraulic controls. Under low mainstem flow conditions, backwater habitats may transform into glides. This being said, AEA has inconsistently and inaccurately applied these classifications to main channel and off-channel habitats.

Mesohabitat classifications are also presented as part of ISR FDA Study 9.6 (June 2014) outside of FAs. These classifications identified run habitat within beaver complexes and interchanged classification of runs and glides (also see NMFS Modification 9). The inaccuracies noted in Study 9.6 could be partly due to the inaccuracies noted in the remote line maps and ground surveys. NMFS recommends that AEA accurately classify mesohabitats based on the classification definitions provided for in the approved plan. Aerial video for the Upper and Middle River main channel and side channels should be revisited and all mesohabitats accurately classified.

Modification 8*:* NMFS recommends that providing the results of the mainstem classification in tables showing lengths of each line on the line maps for all mainstem macrohabitats (main channel and off-channel) as specified in the approved plan.

ISR Study 9.9 (June 2014) did not report study results as specified in the study plan. The study plan (December 2012 RSP) states that, *"The GIS database will create a hierarchical table that will be used to summarize the proportion of habitat by mapped unit of length (Tables 9.9-6 and 9.9-7). This tiered approach would have allowed for summaries at all five levels to support resource study planning. The table would also provide individual identification of all unique habitat types."* However, tables were not provided that could be used to summarize habitat at all five habitat classification levels, or if available electronically were not referenced.

NMFS recommends a table (hard and electronic formats) of results for classification Level 1 through 3 listing out all macrohabitats classified be provided upon completion of an accurate habitat classification, pursuant to the Project's hierarchical habitat model, provide. Every macrohabitat should have a unique identifier so that macrohabitat length, macrohabitat area, mesohabitats, mesohabitat areas, and mesohabitat characteristics can be tied to the same location. The table should be clear enough that the macrohabitats can be identified on the final line map and aerial photographs, including macrohabitat length. This information must be precise enough that the numbers, lengths and areas of each macrohabitat type for each geomorphic reach and river segment can be summarized from these data. .

Additionally, we should be able to identify which of these macrohabitats was ground surveyed. Ground surveyed mesohabitat types, characteristics, and photographs (when provided), within and outside of FAs, should be linked to unique macrohabitat identifiers for every surveyed macrohabitat (100% of Middle River FAs).

Modification 9: NMFS recommends that AEA provide maps and tables showing Upper River and Middle River macrohabitat area as provided for in the approved plan.

RSP Study 9.9 (December 2014) states that, *"All habitat segments will be identified using a mid-channel line, which will provide habitat length; however, off-channel slough habitat will be drawn separately in an area (polygon) in the Middle River to identify the size of each slough and better characterize slough diversity for Instream Flow Study needs. Area mapping will be* *reported separately from the linear database."* Area maps showing the area of each macrohabitat or tables of macrohabitat area have not been provided. This information is necessary to determine the representativeness of FAs and to evaluate sampling unit selection for the FDA and productivity studies. Since aerial video was collected in 2012, it is reasonable to expect accurate and complete line and area maps prior to the second year of field sampling, proposed to occur in 2017. AEA has not identified area mapping as one of the steps to be completed in ISR 9.9 Part C (June 2014).

NMFS recommends that, after conducting accurate and complete habitat classifications; and prior to any additional FDA or River Productivity sampling, maps showing the areas of all off-channel habitats be provided to stakeholders for review and approval. NMFS recommends that the area of the off-channel habitat be calculated for ordinary high water (vegetation line) and at target flows used for habitat classification (10,000 to 12,000 cfs), in order to document any loss or gain in fluvial habitat due to differences in river stage height.

Modification 10: NMFS recommends that AEA complete the ground surveys of 5 to 10 Upper River mainstem mesohabitats and off-channel habitats, classification of mesohabitats for off-channel macrohabitats, and provide Tier III habitat characteristics as provided for in the approved plan. NMFS recommends that AEA complete the ground surveys of 5 to 10 Middle River mainstem mesohabitats and off-channel habitats, classification of mesohabitats within these off-channel habitats, and provide the Tier III habitat characteristics for these sites. NMFS recommends that AEA complete the 100% survey and classification of mesohabitats for all FAs areas as specified in the approved plan. For each macrohabitat within each focus area, provide the percent of each mesohabitat, and Tier III habitat characteristics as specified in the approved plan.

AEA's Upper and Middle River ground surveys have not been conducted as provided for in the approved plan. For the Upper and Lower River, these ground surveys will be the only source of information on the types and abundance of off-channel mesohabitats. This is critical to the study, since the first year FDA sampling was conducted and reported at the mesohabitat level, and must be referenced to habitat maps, if any scientific analysis is to be conducted. These ground surveys will also be used to determine the accuracy of macrohabitat and mesohabitat classification from remote line mapping.

For the Upper and Middle River mainstem, the RSP (December 2012) stated *"a subset of off-channel and main channel habitat units will be ground mapped and include metrics as described for tributaries e.g. depth, width, wood, cover, etc."* The approach described for tributaries states, *"Channel metrics to be subsampled will be collected using a modified U.S. Department of Agriculture, Forest Service (USFS) Tier I and Tier III stream habitat survey protocol (2001)."* The RSP describes ground surveys to be conducted over lengths of 20 times channel width. Tier III protocol includes the collection of the following <u>mesohabitat</u> metrics or characteristics:

- Habitat unit type
- Measured unit length
- Measured average wetted width (three measurements per unit)
- If pool, estimated or measured maximum depth

- If pool, estimated or measured pool crest depth
- Estimated average maximum depth of unit
- Measured width of unit
- Woody debris count in unit
- Estimated percent substrate composition in unit
- Estimated percent undercut, each bank in unit
- Estimated percent erosion, each bank in unit
- Estimated percent riparian vegetation cover in unit
- Dominant riparian vegetation type for each unit
- Estimated percent instream cover in unit
- Photograph of each unit
- GPS location of each unit

Therefore, the study should report each mesohabitat unit type, mesohabitat unit length, woody debris counts, substrate composition, cover, etc., and include a photograph and GPS location for each main channel mesohabitat and off-channel habitat survey over a length of 20 times channel width. These data were not provided in the ISR (June 2014), or SCR (October 2015), and it is not clear that ground surveys collected this information or were conducted over 20 times channel widths.

Ground survey results for the Upper and Middle River mainstem are provided in ISR Study 9.9 Tables 5.1-13 through 5.1.18. For Upper River and Middle River non-focus areas, the tables do not provide information on the types, lengths, or any other habitat metrics for any of the main channel or off-channel habitats surveyed. Average lengths, slopes, widths, and depths of mesohabitats are provided, but there is no information on what Level 3 macrohabitat these Level 4 mesohabitats represent. Provision of average width of a pool from combined main channel, side channels, side sloughs, upland sloughs, and split main channels was insufficient. For every off-channel habitat survey, survey length; including mesohabitat typ , length, and width; woody debris, or any of the other habitat metrics specified within the survey need to be provided. Since only 5 or 10 surveys were proposed to be conducted if all of the metrics were measured, NMFS recommends that AEA clearly provide the PRM of surveyed habitat, macrohabitat type (Level 3), survey length, the type and habitat metrics for each mesohabitat within the survey, and a summary of metrics for that macrohabitat.

FAs were supposed to be surveyed in their entirety, all mesohabitat types classified, and Tier III metrics measured. The ISR states that surveys in FAs are completed or near completion, however the ISR Study 9.9 has not provided information on the types of mesohabitats or habitat metrics within these FAs as provided for in the study plan. A specific example of missing information includes the length of the side slough in FA 128, where AEA has been conducting a number of different studies. In this slough, the classified mesohabitats, and the length of each mesohabitat, depth, substrate type, woody debris, and riparian vegetation should have been provided. There is no information on the number of pools or residual pool depth, nor is there information on the number of beaver dams, dam height, or portion of side slough (by length and area) composed of beaver pond habitat. The photographs and GPS coordinates for each of the mesohabitats within this side slough were also not included. This was supposed to be collected, according to the approved plan. Since this information is not provided in the ISR, and AEA has not responded to NMFS requests for this information, we are left with the conclusion that it has not been collected.

Many of the habitat metrics (substrate, cover, woody debris etc.) are used in models developed by the Instream Flow study. Therefore, in addition to understanding fish habitat associations, these data are critical for determining how habitat metrics that are used in fish habitat models vary among macrohabitats and how these metrics may influence the distribution and abundance of fish species before and after the proposed project. At this point in AEA's reporting, the agencies have been presented with a series of studies that are not integrated in any particular or clear way. This will be best accomplished by a new study for Model Integration. This is particularly concerning for study 9.9, since it was to serve as the basis for valid surveys, reporting, and analyses of data collected in other studies. A New Study request for Model Integration is included as an enclosure.

NMFS recommends that prior to any additional FDA or river productivity sampling, AEA complete an accurate and complete classification of habitats including ground surveys and provide the study results in a single document that reports the information as provided for in the FERC SPD (April 1, 2013).

Modification 11*:* NMFS recommends that beaver pond complex and backwater mesohabitats should be shown on classification maps for the entire Middle River and not just when they occur in FAs.

AEA only shows beaver pond complexes and backwaters in the detailed mesohabitat maps of FAs (SCR Appendix B, October 2015) and not where they occur throughout the Middle River (SCR Appendix A). AEA states that since the FERC determination changed beaver complexes and backwaters from level 3 macrohabitats to level 4 mesohabitats, they only need to be shown in FA off-channel habitats and not in all off-channel habitats outside of FAs. AEA states that they were only required to conduct level 4 mesohabitat classification in FAs because riffles, runs, and pools couldn't be seen well from aerial imagery. However, since beaver dam complexes and backwaters are visible and were largely classified from aerial imagery, they could easily have been shown throughout the Middle River on habitat maps. They were shown where they occurred in off-channel habitats in and out of FAs on previous maps (ISR Appendix A, June 2014), and are to be selected for FDA sampling both inside and outside of FA, so this seems important and feasible.

Beaver-influenced areas are readily apparent and are very important fish habitat, yet only 10 Middle River beaver complexes were identified; NMFS independently identified 20 from the same aerial video footage. AEA identified 8 backwaters on final classification line maps; however, we counted this amount in reach 8 alone.

There was also confusion in AEA's ability to discriminate between beaver influence and physical hydraulic controls. There was no consistency in backwater classifications and many main and side channel backwaters were classified as run/glide mesohabitats. However, since they are not shown where they occur in all off-channel habitats, it remains unclear if backwaters or beaver pond complexes were missed, misidentified, or just not shown on the maps.

Modification 12: NMFS recommends expanding the geographic scope of this study from the three rivers confluence to the Cook Inlet.

NMFS has requested that several of our others studies be extended all the way to the Cook Inlet. Like other sections of river there are at least two and perhaps more distinct habitats in this reach.

The 9.9 Study did not include this lowest 30 miles of the Susitna River but based on preliminary results from the open water flow model, there may be significant stage change and daily fluctuation mid-winter. The overall objective of the describing the effects of Susitna-Watana dam will be better met if this modification is enacted.

Appendix A. Dichotomous key for classifying Susitna River macrohabitats based on AEA's definitions.

AEA Mainstem Classification. Classification is flow dependent. Change in habitat due to differences in channel morphology must be assessed at the same Gold Creek discharge (11,600 cfs).

a. Channel is a dominant main channel. May be more than one channel.............................. c

b. Channel is not a dominant main channel. Flow is < main channel or non-dominant portion (10%) of total flow. Channel is separated from the main channel by an island whose length is ≥ mainstem width... e

c. Channel is a single channel... Single Main Channel

d. Channel is two or more channels divided by an island or bar without vegetation or with annual vegetation. .... Split or Multiple Split Main Channel

e. Channel is turbid and connected to the active main channel..........................Side Channel

f. Overflow channel within the floodplain disconnected from the active main channel....... g

g. Channel may be turbid or clear upstream end not vegetated .... Side slough

h. Channel vegetated at the upstream end, rarely overtopped, water is clear ...Upland slough

Tributary Mouth - Clearwater areas that exist where tributaries flow into the main channel or side channels.

Unclassified Habitat - Downstream from confluence of tributary and side slough or upland slough habitat.

Unclassified Channel - Two or more channels divided by islands or bars with perennial vegetation.

Appendix B. Table comparing AEA habitat classification from line maps with classification from ground surveys.

Table B1. Comparison of classification from ground surveys (AEA Appendix D) with revised line maps (AEA Appendix L, Revised Appendix A). UC is unclassified, BW is backwater, CP is clearwater plume, SM is split main, MS is multiple split, BC is beaver complex, MC is main channel, SC is side channel, SS is side slough, and US is upland slough. A 1 = different classification, a 0 indicates no difference in classification.

Appendix D Map	App D Macrohabitat	App A or L Macrohabitat	Revised Line Map	Different
14 of 31	UC	BW	38 of 55	1
14 of 31	CP	CP	38 of 55	0
31 of 31	MC	MC	55 of 55	0
30 of 31	SM	MC	54 of 55	1
28 of 31	MC	MC	52 of 55	0
27 of 31	MC	MC	51 of 55	0
26 of 31	MC	MC	50 of 55	0
20 of 31	MC	MC	44 of 55	0
18 of 31	MC	MC	42 of 55	0
16 of 31	MS	MC	40 of 55	1
15 of 31	MC	MC	39 of 55	0
14 of 31	MC	MC	38 of 55	0
13 of 31	SM	MC	37 of 55	1
13 of 31	MC	MC	37 of 55	0
12 of 31	MC	MC	36 of 55	0
9 of 31	MC	MC	29 of 55	0
6 of 31	MC	MC	26 of 55	0
4 of 31	MC	MC	24 of 55	0
2 of 31	MC	MC	22 of 55	0
17 of 31	MS	MS	41 of 56	0
30 of 31	SC	SC	54 of 55	0
30 of 31	SC	SC	54 of 55	0
30 of 31	SC	SC	54 of 55	0
30 of 31	SC	SC	54 of 55	0
30 of 31	SC	SC	54 of 55	0
30 of 31	SC	SC	54 of 55	0
30 of 31	SS	SC	54 of 55	1
27 of 31	SC	SC	51 of 55	0
26 of 31	US	SC	50 of 55	1
26 of 31	SM	SC	50 of 55	1
26 of 31	SS	SC	50 of 55	1

Appendix D Map	App D Macrohabitat	App A or L Macrohabitat	Revised Line Map	Different
21 of 31	SC	SC	45 of 55	0
20 of 31	SC	SC	44 of 55	0
20 of 31	SC	SC	44 of 55	0
20 of 31	SC	SC	44 of 55	0
20 of 31	SC	SC	44 of 55	0
20 of 31	SC	SC	44 of 55	0
20 of 31	SS	SC	44 of 55	1
19 of 31	SC	SC	43 of 55	0
16 of 31	SC	SC	40 of 55	0
14 of 31	SC	SC	38 of 55	0
13 of 31	SC	SC	37 of 55	0
13 of 31	SC	SC	37 of 55	0
13 of 31	SC	SC	37 of 55	0
13 of 31	SC	SC	37 of 55	0
13 of 31	BW	SC	37 of 55	1
13 of 31	SS	SC	37 of 55	1
13 of 31	SS	SC	37 of 55	1
9 of 31	SM	SC	29 of 55	1
6 of 31	SS	SC	26 of 55	1
6 of 31	SC	SC	26 of 55	0
6 of 31	SC	SC	26 of 55	0
2 of 31	SC	SC	22 of 55	0
2 of 31	SC	SC	22 of 55	0
31 of 31	SM	SM	55 of 55	0
31 of 31	SM	SM	55 of 55	0
31 of 31	SM	SM	55 of 55	0
31 of 31	SM	SM	55 of 55	0
31 of 31	SM	SM	55 of 55	0
31 of 31	SC	SM	55 of 55	1
28 of 31	SM	SM	52 of 55	0
26 of 31	SM	SM	50 of 55	0
26 of 31	SM	SM	50 of 55	0
26 of 31	SM	SM	50 of 55	0
26 of 31	SM	SM	50 of 55	0
16 of 31	MS	SM	40 of 55	1
16 of 31	MC	SM	40 of 55	1
16 of 31	SM	SM	40 of 55	0
14 of 31	SM	SM	38 of 55	0
14 of 31	SM	SM	38 of 55	0

Appendix D Map	App D Macrohabitat	App A or L Macrohabitat	Revised Line Map	Different
10 of 31	SM	SM	34 of 55	0
9 of 31	SM	SM	29 of 55	0
31 of 31	SS	SS	55 of 55	0
30 of 31	SS	SS	54 of 55	0
30 of 31	MC	SS	54 of 55	1
30 of 31	SS	SS	54 of 55	0
23 of 31	SS	SS	47 of 55	0
21 of 31	SS	SS	45 of 55	0
16 of 31	SS	SS	40 of 55	0
16 of 31	SS	SS	40 of 55	0
16 of 31	SS	SS	40 of 55	0
15 of 31	BW	SS	39 of 55	1
15 of 31	SS BC	SS	39 of 55	1
13 of 31	SS BC	SS	37 of 55	1
6 of 31	SS	SS	26 of 55	0
6 of 31	SS	SS	26 of 55	0
25 of 31	SS BC	SS BC	49 of 55	0
31 of 31	SC	UC	55 of 55	1
30 of 31	CP	UC	54 of 55	1
30 of 31	BW	UC	54 of 55	1
27 of 31	CP	UC	51 of 55	1
26 of 31	SM	UC	50 of 55	1
26 of 31	SM	UC	50 of 55	1
26 of 31	BW	UC	50 of 55	1
17 of 31	SS	UC	41 of 56	1
6 of 31	SC	UC	26 of 55	1
25 of 31	SS	UC BW	49 of 55	1
30 of 31	US BC	US	54 of 55	1
27 of 31	US BC	US	51 of 55	1
26 of 31	US BC	US	50 of 55	1
25 of 31	US BC	US	49 of 55	1
25 of 31	US BC	US	49 of 55	1
23 of 31	SS	US	47 of 55	1
23 of 31	US	US	47 of 55	0
20 of 31	US	US	44 of 55	0
15 of 31	US	US	39 of 55	0
15 of 31	BW	US	39 of 55	1
15 of 31	US	US	39 of 55	0
15 of 31	CP	US	39 of 55	1

Appendix D Map	**App D Macrohabitat**	**App A or L Macrohabitat**	**Revised Line Map**	**Different**
15 of 31	US BC	US	39 of 55	1
14 of 31	US BC	US	38 of 55	1
13 of 31	US Dry	US	37 of 55	0
25 of 31	US BC	US BC	49 of 55	0
18 of 31	US BC	US BC	42 of 55	0
14 of 31	US BC	US BC	38 of 55	0
15 of 31	SS	US BW	39 of 55	1

9.11 Fish Passage Feasibility at the Watana Dam

ISR Review and Study Modifications

The Alaska Energy Authority (AEA) has developed this study to identify and evaluate ways to move spawning fish above the dam and safely allow juvenile fish to out migrate back down the Susitna River.

Study Objectives

The study was laid out in tasks but these seem to be similar to objectives. The tasks, as stated in the Federal Energy Regulatory Commission (FERC) Study Plan Determination, (2/1/2013) are:

1. Establish a Fish Passage Technical Work Group (Fish Passage TWG) with representatives from state and federal agencies, Commission staff, and other interested licensing participants.
2. Compile existing and salient background information and prepare workshop materials including further development of evaluation criteria and an evaluation process.
3. Conduct a site reconnaissance to observe conditions and collect information, as appropriate, for concept development.
4. Facilitate a two-day brainstorming workshop with the Fish Passage TWG to identify fish passage concepts. AEA would then organize the concepts and, with input from the Fish Passage TWG, perform an initial fatal-flaw analysis to eliminate any concept that cannot meet basic criteria.
5. Develop an evaluation matrix to advance the existing state of each alternative's conceptual design and allow a relative comparison of the alternatives. This information would be presented at a final workshop, with the goal of selecting a final list of alternatives for refinement by AEA in Task 6.
6. Preparation of an opinion of probable construction and operating cost for each alternative, describing operational protocols and issues, addressing comments from Task 5, performing final runs of the biological performance tool, preparing a final quantitative evaluation of the alternatives using the final evaluation matrix and evaluation criteria, and addressing constructability issues and any remaining data needs or significant risks.

The FERC Study Plan Determination did not order any modifications to the Revised Study Plan (RSP).

NMFS Study Modifications

Note that Modifications 5-1 and 6-1 might be more appropriate under studies 9.5 Fish Distribution Upper River and 9.7 Glacier and Runoff Changes.

2-1 Expand the literature review to better understand how well adult and juvenile riverine species navigate through a still water body.

5-1 Determine the (present and future) timing when out migrating juvenile salmon would need to be collected from tributaries and moved over the dam by combining information from Study 9.5 and Study 7.7.

6-1 Complete 9.5 FDA Upper River study so the number of tributaries where fish need to be moved is determined (Objective 5 and 6).

Review by Study Objective

Objective 1: *Establish a Fish Passage Technical Work Group (Fish Passage TWG) with representatives from state and federal agencies, Commission staff, and other interested licensing participants. Four workshops would be scheduled at study milestones which are task 3 -6 below.*

A diverse Technical Work Group with adequate representation from most agencies was established.

National Marine Fisheries Service (NMFS) has no modifications to Objective 1.

Objective 2: *Compile existing and salient background information and prepare workshop materials including further development of evaluation criteria and an evaluation process. The review would allow the Fish Passage TWG to become familiar with the operational, physical, hydrologic, and biological setting of the proposed Watana dam.*

The applicant gathered together much of the biological, physical and operational information that will be required to develop and analyze the fish passage options at the site. Chinook Salmon, Artic Grayling and Burbot were selected as representative species to evaluate for fish passage.

Uncertainty exists about the locations above the dam where Chinook Salmon and possibly Sockeye Salmon spawn. The fish passage study will need to lay out not just how the fish pass over the physical dam structure but also if they can navigate through a large body of flat water to find their natal stream. While this information is crucial to the Fish Passage Study it is the role of 9.5 Fish in the Upper River, and 9.7 Salmon Escapement to provide this information.

Modification 2-1: Expand the literature review to better understand how well adult and juvenile riverine species navigate through a still water body.

Knowing whether a Chinook Salmon needs only to be moved over/around a concrete barrier or whether it needs to be moved around the still water impoundment is important. A review of other Chinook Salmon passage efforts on storage dams could add clarity.

The study was not conducted as provided for in the approved study plan because salient information about whether adult and juvenile fish will efficiently navigate miles of flat water without negative impacts was not included.

Objective 3: *Conduct a site reconnaissance to observe conditions and collect information, as appropriate, for concept development.*

A site visit was conducted.

NMFS has no modifications to Objective 3.

Objective 4: *Facilitate a two-day brainstorming workshop with the Fish Passage TWG to identify fish passage concepts. AEA would then organize the concepts and, with input from the Fish Passage TWG, perform an initial fatal-flaw analysis to eliminate any concept that cannot meet basic criteria.*

A brainstorming workshop was carried out and over 100 concepts were identified. Shortly after this the project was put in abeyance and it is not clear to what extent the concepts were organized.

While this objective got off to a good start it has not been completed. Modification 5-1 might add to the fatal flaw analysis. It is described under Objective 5.

Objective 5: *Develop an evaluation matrix to advance the existing state of each alternative's conceptual design and allow a relative comparison of the alternatives. This information would be presented at a final workshop, with the goal of selecting a final list of alternatives for refinement by AEA in Task 6.*

This objective has not been started.

Modification 5-1: Determine the timing (now and in the future) when juvenile salmon would need to be collected from tributary mouths, moved across the reservoir and finally moved over the dam by evaluating current and future outmigration timing in 9.5 FDA Upper River and coupling that with information about earlier melt out and warmer stream temperatures in the 7.7 Glacier and Runoff Changes study.

Evaluating the relative merits of outmigrating fish passage design is difficult if you don't know if the action needs to happen before breakup, during breakup or after breakup. Although we know approximately when Upper River breakup happens now the thick layer of ice on the dam might break up earlier or later. The feasible options both for capturing and transporting juvenile salmon will vary with the extent of the ice cover.

The study objective will not be able to be conducted as described in the approved study plan unless the timing of outmigration relative to breakup is determined, now and in the future.

Objective 6: *Preparation of an opinion of probable construction and operating cost for each alternative, describing operational protocols and issues, addressing comments from Task 5, performing final runs of the biological performance tool, preparing a final quantitative evaluation of the alternatives using the final evaluation matrix and evaluation criteria, and addressing constructability issues and any remaining data needs or significant risks.*

Fieldwork to address this objective has not been started.

Modification 6-1: NMFS recommends the number of tributaries above the reservoir where fish spawn be determined. Without this information, the scale and therefore cost of any fish passage operation is unknown.

Without this knowledge it will be impossible to evaluate the cost of various fish passage alternatives. For example if only two tributaries had spawning habitat, moving juveniles from their native streams and over the dam by helicopter, would be expensive but logistically possible. If the salmon spawn in 15 different tributaries this alternative would probably be economically infeasible.

The study has not yet been conducted as provided for because Objective 6 cannot be completed with the existing information.

<u>Summary Comments</u>

The first three objectives or tasks were completed in accordance with the study plan. A successful TWG meeting identified over 100 concepts for fish passage and AEA narrow that list somewhat. Objectives 5 and 6 have not been started. To complete these last two objectives additional information on the current and future timing of outmigration needs to be collected. The applicant was proceeding as planned on this study until the abeyance was put in place. The work to date followed the study design.

9.12 Fish Passage Barriers in the Middle and Upper Susitna River and Susitna River Tributaries Study

ISR Review and Study Modifications

The Alaska Energy Authority (AEA) has developed studies to identify and evaluate existing conditions and potential project effects to fish passage into tributaries, sloughs, and side channels of the Susitna River.

Study Objectives

The study objectives as stated in the Federal Energy Regulatory Commission (FERC) Study Plan Determination (2/1/2013) are:

1. Locate and categorize all existing fish passage barriers (e.g., falls, cascades, beaver dams, road or railroad crossings) located in selected tributaries in the Middle and Upper Susitna River,
2. Locate the barriers using a global positioning system (GPS), identify the type (permanent, temporary, seasonal, partial), and characterize the physical nature of any existing fish barriers located within the Project's zone of hydrologic influence (ZHI),
3. Evaluate the potential changes to existing fish barriers (both natural and man-made) located within the Project's ZHI, and
4. Evaluate the potential creation of fish passage barriers within existing habitats (tributaries, sloughs, side channels, off-channel habitats) related to future flow conditions, water surface elevations, and sediment transport.

In the Study Plan Determination (2/1/2013), FERC actually requested several changes/additions to the above four objectives.

The general study approach is to:

- identify target fish species and life stages,
- develop fish passage criteria for these species and life stages,
- identify all the locations of migration barriers under existing conditions, and
- evaluate how project operations can influence fish passage.

NMFS Study Modifications

National Marine Fisheries Service (NMFS) recommends the following seven modifications, further details and justification are described under the relevant Study Objective:

1-1 In Upper River tributaries collect field data at the necessary spatial scale and model velocity/depth in two dimensions to evaluate fish passage.

1-2 In Middle River tributaries from Portage Creek down collect data at the necessary spatial scale and model velocity/depths in two dimensions to evaluate fish passage criteria.

2-1 In the Middle River focus areas conduct winter field surveys of velocity/depth longitudinally through all sloughs to identify current fish barriers.

2-2 Install water level loggers in all Middle River focus areas and develop discharge rating curves so velocities can be predicted during ice development.

3-1 In the Upper River tributaries collect field data at the necessary spatial scale and model all fish passage barriers (velocity, leap and depth) from the low pool elevation to first leap barrier above the high pool elevation.

3-2 Incorporate results from the 8.6 riparian instream flow and 6.6 geomorphology study to model tributary delta formation and channel morphology, water depths, and water velocities within the reservoir varial zone. (This is similar to modifications 2.5 in Study 6.6)

G-1 (Global) Expand the geographic extent of this study to include the Lower River from Talkeetna to the Project River Mile 24.

General Comments

The National Marine Fisheries Service (NMFS) believes that the approved study plan remains incomplete and does not provide the methods necessary to meet the study objectives. This is largely because a Technical Working Group was not organized during the licensing process to develop suitable methods. The proposed study has identified target fish species, life stages, and proposed passage criteria for these species and life stages. Passage criteria are incomplete, and the specific criteria that will be used to identify leap barriers, depth barriers, or velocities and times to fish exhaustion (prolonged and burst speeds) are still unclear. Identifying fish passage barriers using these proposed criteria requires measuring or modeling water depths and water velocities over distance, measuring or modeling leap heights and pool depths and comparing modeled hydraulic characteristics to target fish burst and sustained swimming speeds and leaping ability. The approved study plan does not describe the methods that will be used to model these hydraulic and physical habitat characteristics (outside of focus areas), or the field data to be collected as model input for sites within the ZHI where barriers are likely to occur (Upper River and Middle River tributaries, beaver dams, railroad crossings).

Methods have not been developed to model post-project hydraulic conditions necessary to evaluate passage criteria in Upper River tributaries at proposed reservoir pool elevations under different project operational scenarios or to model potential post project changes to Upper River tributary stream channel geometry. For example, what is the distance to the first migration barrier, including velocity barriers, for all target fish species currently, and how does this vary under different operational scenarios (reservoir pool elevations), tributary discharge, and migration timing? How will the post-project loss of upper river tributary riparian vegetation and changes in sediment transport alter channel geometry in the reservoir zone between high and low pool elevation (varial zone) and how will this influence fish passage under different operational scenarios?

The FERC study determination (4/1/2013) stated that, "A reasonable approach to address this potential project effects would be for AEA to specify the methods (e.g. two-dimensional modeling or other modeling approach) that it would apply at each off-channel and tributary delta location for the depth barrier analysis after it selects its proposed study sites in consultation with the TWG. This would include an explanation of its proposed methods during both the open-water period for adult and juvenile fish, and ice-cover period for juvenile fish, both of which would be necessary to evaluate project effects (section 5.9(b)(5))." Since this FERC recommendation has not been accomplished, the study has not been implemented as described in the approved plan and is subject to recommended study modifications necessary to meet study objectives.

AEA has not described how they intend to model hydraulic conditions in the Middle and Lower River tributaries under variable mainstem and tributary flows. Thalweg surveys of depth and velocity at a single tributary flow at a less than 10 meter intervals, as shown in the Initial Study Report (ISR) are insufficient for the evaluation of passage criteria for target fish species, and cannot be used to model hydraulic conditions (in two dimensions) and fish passage under variable mainstem water surface elevations and tributary flows. Modeling efforts being conducted in study 6.6 have not been described, do not specify that water velocity will be modeled, are only being applied to a subset of streams, and do not clarify how passage criteria will be evaluated.

A two-dimensional model of hydraulic conditions has been developed for a mainstem slough at one focus area (FA-128). This may be an effective method to evaluate passage criteria, depending on the accuracy of modeled depths and velocities and the ability to account for residual groundwater flows. Modeled depths that are accurate to the nearest foot (as shown in the Proof of Concept presentations) may not be accurate enough to evaluate migration barriers to juvenile salmon, and the groundwater study has yet to present quantitative measures of residual flows in off-channel habitats due to groundwater discharge. This study has not demonstrated the ability to model hydraulic conditions in other focus areas.

Current ice processes modeling is one-dimensional and ice thickness is not modeled or measured. Winter hydraulic modeling assumes a one meter ice thickness which is inaccurate; therefore, all modeled depths and velocities under the ice are inaccurate. Winter passage within off-channel habitats may be dependent upon residual flows from groundwater discharge; however, the groundwater study has yet to provide quantitative measures or models of groundwater flows within focus areas. Since modeled depths and velocities are inaccurate and residual flows unknown, the study will not be able to evaluate passage criteria for target fish species during winter. This is a critical time period and load-following project operational scenarios are predicted to cause significant changes in water surface elevations and velocities in off-channel habitats during winter.

Flow routing under proposed operational scenarios indicates that project effects will extend downstream from the three rivers confluence. Adult salmon studies have documented salmon spawning in lower river mainstem side slough and side channel habitats and juvenile salmon studies have confirmed the importance of beaver dams as rearing habitats. The FERC study determination states, that "If the results of the 2013 study in the Middle River (as documented in the ISR) indicate that the project would cause significant adverse effects on fish passage into tributaries and off-channel habitats, and/or the preliminary results from the flow-routing, instream flow, or geomorphology modeling efforts indicate that project effects would extend downstream of the three rivers confluence, additional study areas could be added downstream in subsequent study years (sections 5.15(d) and 5.15(e))."

Review by Objective

Objective 1: *Locate and categorize all existing fish passage barriers (e.g., falls, cascade, beaver dam, road or railroad crossings) located in selected tributaries in the Middle and Upper Susitna River (Middle River tributaries to be determined during study refinement).*

Modification 1-1: For Upper River tributaries, NMFS recommends collecting field data and model velocities and water depths over distance to determine the location of the first velocity migration barrier upstream from the mainstem Susitna River for all target fish species and life stages. As an alternative to AEA proposed velocity criteria, the NMFS recommends that AEA, using 2-D modeling in Middle River Tributaries, develop slope-distance passage criteria for all target fish species and life stages, and conduct field longitudinal surveys in Upper River tributaries to identify the distance from the mainstem to the first existing barrier (depth, velocity, or leap) to fish passage for all target fish species and life stages.

AEA states in their Study Implementation Report (SIR) that all field data collection has been completed; however, Upper River surveys have only been conducted to identify adult salmon leap barriers (water falls). Based on Upper River Fish distribution (Study 9.5), adult salmon and other target fish species migrating from the Susitna River probably encounter velocity barriers at some distance downstream from the identified falls. Understanding current conditions, and meeting study objectives, requires an understanding of available tributary habitats to target fish species determined as the distance upstream from the Susitna River to the first barrier. Evaluating project effects will be accomplished by comparing the currently available habitat for all target fish species, with the distance fish can migrate upstream from the reservoir into tributaries under different reservoir pool elevations (AEA Objective 3). As there are other barriers to fish passage than water falls, AEA cannot assume that reservoir inundation of water falls will result in an increase in available tributary habitat relative to current conditions.

The identification of velocity barriers requires comparing tributary velocities with fish burst and sustained swimming speeds (e.g. Fish Xing). Velocity barriers occur where minimum cross-section water velocities (with sufficient depth) exceed target fish species burst swimming speeds. Barriers can also occur where velocities are greater than prolonged swimming speeds over a distance that results in fish exhaustion. Water velocities are typically modeled using relationships with discharge, channel slope, cross-sectional area, and bed roughness to determine locations of barriers. Slope-distance relationships are sometimes used as a surrogate for velocity. AEA has provided no information on how passage criteria will be evaluated in Upper River tributaries to determine the location of temporary or permanent velocity (or depth) barriers.

We recommend that AEA use aerial videography and results from the Habitat Characterization study (Study 9.9) to identify locations of potential velocity or depth passage barriers to target fish species in Upper River tributaries. AEA should conduct field surveys to measure channel cross-sections, water velocity, water depth, channel bed and water surface slopes, and substrate size distribution, and any other information necessary to model water velocity. AEA should use regional regressions developed by U.S. Geological Survey to estimate tributary discharge. AEA should propose passage flows based on estimated discharge and the periodicity of target fish species. AEA should use modeled velocities to evaluate passage criteria for target fish species in order to identify the location of the first velocity barrier upstream from the Susitna River in all Upper River tributaries.

We recognize that modeling water velocities in Upper River tributaries to evaluate AEA's passage criteria may be onerous. As an alternative, NMFS recommends that AEA identify the combination of channel slope and distance that will likely result in velocity barriers. For example, the Alaska Forest Resources and Practices Act Regulations (11 AAC 95.265) have developed an approach to determining the upper extent of anadromous waters based on a combination of surface water slope and distance. AEA, using field measures of channel width, depth, and substrate obtained through the Habitat Characterization study (Study 9.9) should be able to simulate water velocities and develop slope and distance combinations that would result in water velocities that exceed fish passage criteria of target fish species. Tributary water surface elevations over distance may be available from LiDAR data or may require additional field work.

This study was not conducted as provided for in the approved study plan because the only type of fish barrier mapped or considered were waterfalls.

Modification 1-2: For all Middle River tributaries downstream from and including Portage Creek, NMFS recommends collecting field data and model water velocities in two dimensions to evaluate passage criteria for target fish species and life stages.

Survey data provided within the ISR and SIR are insufficient to model water velocities and water depths at Middle River tributary mouths at multiple mainstem and tributary flows to evaluate passage criteria for target fish species. Similar to Upper River tributaries, methods have not been developed to assess passage criteria in tributary mouths within or outside of focus areas. In order to evaluate passage criteria, cross-sectional and longitudinal surveys must be conducted at a scale that will allow for modeling water depths and velocities at multiple different tributary and mainstem flows. Survey data presented in the ISR and SIR do not provide the detail to evaluate passage criteria to locate velocity and depth barriers and AEA has not demonstrated the modeling approach that will be used as recommended by the FERC.

Survey data in ISR 9.12 Appendix B shows water depth, point velocity, and slope data along the channel thalweg from the Susitna River to the upper zone of hydraulic influence. Depth data are point measures, and while we presume that the thalweg is the point of maximum depth, we have no knowledge of depths longitudinally between survey points and there are often large distances between points. For example, at Lane Creek water depth is 1.2 feet at station 0 and 0.5 feet at station 17.5. Results do not show if there is a point between station 0 and 17.5 where a single water depth may present a migration barrier. In Fourth of July Creek there is a 26 foot distance between the first two survey points, with no information on water depths between these two points. Results also do not provide any measure of tributary discharge or the portion of flows represented by this discharge.

Velocity data in ISR 9.12 cannot be used to evaluate velocity barriers to juvenile salmon. While passage criteria have not been confirmed (see Appendix B), thalweg velocities at many of the tributary survey points exceed the burst swimming speeds of juvenile Coho Salmon and Arctic grayling. However, there are likely lower velocities on the channel margins, but these areas were not measured. We are unable to plot the minimum cross-sectional velocities over distance to test whether at these mainstem flows and tributary flows burst swimming speeds are exceeded or if combinations of velocity and distance will exceed fish swimming abilities (fish become exhausted). Based on current data, barriers likely exist at most tributaries under low mainstem flow conditions.

AEA must demonstrate an approach through which identified passage criteria can be evaluated for target fish species and life stages at multiple mainstem and tributary flows.

The study was not conducted as provided for in the approved study plan because longitudinal surveys up tributary contain too little information to determine if the fish could pass.

Objective 2: *Locate using geographic information system (GIS), identify the type (permanent, temporary, seasonal, partial), and characterize the physical nature of any existing fish barriers located within the Project's ZHI.*

AEA has proposed passage criteria; however, final criteria have not been established for many fish species and life stages. To meet this objective, passage criteria must be finalized, and methods developed to evaluate passage criteria throughout the project area, field data collected to model leap heights and distances, water depths, and water velocities. Currently the only methods proposed are based on open water hydraulic modeling within Middle River focus areas.

Modification 2-1: NMFS recommends conducting winter field surveys during January and February in all Middle River focus areas to measure water depth and velocity longitudinally throughout all side channels, side sloughs, and upland sloughs to identify locations that are currently barriers to fish migration.

The ice processes study is currently unable to accurately model water velocities or depths in main channel or off-channel habitats when ice cover is present. The current location of depth and velocity barriers to fish migration and total available winter habitat under current conditions is unknown. We have documented potential velocity barriers in tributary mouths and side sloughs, and depth barriers to fish migration in side sloughs, upland sloughs, and tributary mouths that are influenced by mainstem ice formation and location (Davis et al. 2013, Davis et al. 2015). During low winter flows, sloughs and side channels can consist of isolated pools with no open surface water connection between pools, or with the main channel, resulting in multiple depth barriers. For example, no open water was found at the mouth of Oxbow I (FA 113) during the winter of 2014 or the mouth of Rabideux Creek during the winter of 2013. Alternately, mainstem ice formation can divert mainstem flows into the upstream ends of side sloughs or side channels resulting in velocities within the channel that exceed the prolonged and burst swimming speeds of juvenile salmon. We have not conducted extensive winter surveys to document the extent of these conditions during winter.

Measures of depth and water velocity in side channels and off-channel habitats also will provide information that can be used to calibrate winter ice processes and hydraulic models.

The study was not conducted as provided for in the approved study plan because winter habitat connectivity and barriers for juvenile fish has not been examined.

Modification 2-2: The NMFS recommends installing water level loggers and develop stage discharge relationships (rating curves) at multiple locations in all Middle River focus area side sloughs and side channels in order to estimate water velocity and fish passage barriers during winter ice development. Specifically NMFS recommends 2 water level loggers at potential juvenile barriers in 5 focus areas: This is an acknowledgement that AEA cannot physically develop quality scientific winter rating curves for all 10 focus areas.

The AEA study objective is to locate and categorize all fish passage barriers in the Middle River. We have observed that during ice development rising river stage heights can result in backwater conditions at the mouths of side sloughs and side channels or cause breaching flows at the upstream ends of these channels. Backwaters into the mouths of side sloughs and side channels can increase stage height approximately 4 feet (see AEA 2013-2014 Winter IFS Study). Changing ice conditions can shift flows downstream resulting in rapid draining of the backwater causing water velocities in the slough mouth to exceed juvenile salmon prolonged or burst swimming speeds. Similarly, breaching flows can increase water velocities over prolonged or burst swimming speeds of juvenile salmon in side sloughs and side channels during mainstem ice formation. These high water velocities may exclude fish from these channels for the remainder of the winter which has significant implications to evaluating weighted usable area through instream flow analyses and fish habitat modeling. Load following during winter also may result in periodic breaching flows into off-channel habitats causing short-term velocity migration barriers.

The study was not conducted as provided for in the approved study plan because winter barriers to juvenile fish passage were not investigated.

Objective 3: *Evaluate the potential changes to existing fish barriers (both natural and man-made) located within the Project's ZHI.*

Modification 3-1: NMFS recommends that, for Upper River tributaries, AEA collect field data and conduct two-dimensional modeling of water depths and velocities to locate all velocity, depth, and leap barriers to target fish species from low pool elevation under low water years and all operational scenarios upstream to the first barrier upstream from high pool elevation.

The fish passage barriers study has located all waterfalls that are leap barriers to adult salmon, and the study implies that inundating these barriers in the reservoir will increase available stream habitat for target fish species. However, AEA has provided no information on other types of potential barriers within stream channels upstream of the reservoir proposed pool elevations. Additional barriers to fish migration potentially occur in Upper River tributaries other than waterfalls. Locating these barriers is necessary to determine how far target fish species can migrate from the reservoir up tributaries and to compare available tributary habitat. We recommend that AEA implement the methods described previously for Upper River tributaries (recommendation 1.1) to identify the location of all passage barriers within and upstream from proposed low pool elevation to high pool elevation.

The study was not conducted as provided for in the approved study plan because too little information is known about upper river tributaries at assess project effects on fish barriers.

Modification 3-2: The NMFS recommends a study modification that would incorporate results from the 6.6 geomorphology study and 8.6 riparian instream flow to model tributary delta formation and channel morphology, water depths, and water velocities within the reservoir varial zone. (This is similar to modifications 2.5 in Study 6.6)

Creation of a reservoir will modify riparian vegetation and sediment transport of tributaries within the varial zone. Upland vegetation inundated by the reservoir will perish and soil conditions will be altered. Bed sediments transported in tributaries will be deposited in the reservoir potentially creating a delta at the tributary mouth. During low pool elevations tributaries will flow through a tributary delta and will be distributed laterally or vertically. We recommend that the Fish Passage Barriers study coordinate with the riparian vegetation and geomorphology study to model post-project changes in tributary channel geometry, and ultimately model post-project water velocities and depths to evaluate fish passage criteria.

The study was not conducted as provided for in the approved study plan because we know too little about the potential shape and form new delta fans to understand if fish will be able to pass through them.

Objective 4: *Evaluate the potential creation of fish passage barriers within existing habitats (tributaries, sloughs, side channels, off-channel habitats) related to future flow conditions, water surface elevations, and sediment transport.*

The ability of current studies to meet this objective has not been determined. AEA will need to demonstrate the ability to model changes in bed morphology in (1) main channel and off-channels within focus areas, (2) Upper River tributaries in the reservoir varial zone, and (3) all Middle and Lower River tributary mouths. AEA will need to demonstrate the ability to (1) accurately model water velocity and depth during open water and ice covered conditions in all Middle River focus areas under all project operational scenarios, (2) model water velocities and depths in all Upper River tributaries within the reservoir varial zone under tributary passage flow conditions, (3) model water depths and leap heights at beaver dams, and (4) model water velocities and depths in all Middle River tributaries under all mainstem stage heights expected under all operational scenarios, and tributary passage flow conditions. AEA will need to demonstrate the ability to evaluate passage criteria at all of these locations and under all operational scenarios.

This objective has not been met. Modification 3-2 also applies well to Objective 4.

Modification Global -1: NMFS recommends expanding the geographic scope of this study 9.12 to include the Lower River from Talkeetna to PRM 24.

AEA describes the Lower Susitna River Segment (defined as the approximate 102-mile section of river between the Three Rivers Confluence and Cook Inlet) as representative habitat that would be less susceptible to project effects. However, the scientific literature related to riverine hydropower impacts does not support that assumption (Drinkwater and Frank 1994; Rosenberg et al. 2000). Furthermore, initial findings from ISR 8.5 Instream Flow Study Part C – Appendix K (AEA 2014c) indicate that post Project operations will change the flow hydrograph in the Middle and Lower river, resulting in maximum potential water level changes ranging from 9.7 feet near the proposed dam, 5.7 feet near Gold Creek, and 2.1 feet near Susitna Station in the Lower Susitna River, below the Yentna River and ~20 miles upstream from Knik Arm. This amount of water level change may have a large effect on connectivity between the main channel, side channels, off-channels, beaver ponds, and tributaries. Additionally, the predicted hourly water level effects associated with ramping rates for hydro peaking (load following flows) ranged from 0 to 2.1 feet under dry conditions and 0 to 8.0 feet under wet conditions near the dam site, 0 to 4.1 feet near Gold Creek, 0 to 4.0 feet near the Sunshine gage in the upper reach of the Lower Susitna River, and approximately 0 to 2.0 feet near the Susitna gage in the Lower Susitna River just below the confluence with the Yentna River. This indicates that the ramping rates associated with a hydro-peaking operation will have large effects on the water surface elevations throughout the Middle and Lower Susitna River. In turn, these flow alterations will affect habitat conditions, lateral and longitudinal habitat connectivity, river processes (instream flow and riparian), and ice processes (flow under and over existing ice formations).

We anticipate significant alteration to the Lower River will occur as a result of the proposed project operations and therefore we request a geographic expansion study modification to include the Lower Susitna as necessary to better understand the extent to which the proposed project may affect focal species and their life stage-specific habitats. This study request involves the ability of salmonids and other target species to gain access to and from main channel, side channel, and off channel habitats including beaver ponds. Other study requests will evaluate the effect of flow fluctuation on the survival of fishes.

The goal and objectives of this study modification are consistent with those reported in the Final Study Plan for Fish Passage Barriers (9.12). The goal is to evaluate the potential effects of Project-induced changes in flow and water surface elevation on free access of fish into, within, and out of suitable habitats (fish passage) in the Lower Susitna River (Three Rivers confluence (RM 98.5) to at least Susitna Station (RM 24.9)). This goal will be achieved by meeting the Study 9.12 objectives.

We recommend that a minimum of six Lower River side sloughs or side channels that support salmon spawning and a minimum of six representative beaver dams that support juvenile salmon rearing are selected to evaluate project effects to fish passage. At least one side channel or side slough should be selected that supports Eulachon spawning. All road or railroad culverts within the ZHI need to be evaluated as potential fish passage barriers. Specific study locations should be identified by the study planning team, including consultation with the Services, prior to the field investigation in the Lower River; however, all six sloughs should not be located within the same complex but distributed systematically from river mile 24 to 98. The number of study sites within each slough should be sufficient to conduct an evaluation of Project effects that may affect access to habitats used by each life stage of anadromous salmonids and other target species. Because budget constraints will limit the total number of study sites, study site selection should consider areas where flow fluctuations caused by the Project are most likely to affect access to habitats by juvenile and adult fishes during each season of the year. Load following flows are expected to be greatest during winter months, indicating that fish passage during winter months must be evaluated.

Potential Project effects on spawning and rearing activities of salmon and other fishes would be addressed through the Instream Flow Study (Study 8.5), but it is anticipated that the Instream Flow Study would coordinate with the Fish Passage Study and provide necessary data describing channel characteristics and hydrology to evaluate fish passage at selected sites.

Hydraulic modeling (one-dimensional) during the ice free and during ice cover, similar to the approach being applied to the mouth of Birch Creek, should be used to assess fish passage criteria in sloughs and side channels and beaver dams. Fish Xing should be used to evaluate passage criteria through road and railroad culverts at all mainstem water surface elevations.

Within sloughs and side channels longitudinal surveys should be conducted during low water periods to identify those locations within a slough or side channel that are potential fish passage barriers. Cross-section transects and hydraulic modeling should occur at these locations and at the upstream end of the slough or side channel to determine the water surface elevation that results in main channel breaching.

The primary information to be obtained from the proposed study modification is (1) determine the extent of potential changes to existing fish barriers (both natural and man-made) located within the Project's zone of hydraulic influence throughout the Lower Susitna River, and (2) determine the extent to which Project-related flows create or exacerbate fish passage barriers within existing habitats (tributaries, sloughs, side channels, off-channel habitats, road and railroad culverts), including the effects of water surface elevation and sediment transport. This will be accomplished with methodologies reported in the Final Study Plan and Implementation Plan while also considering comments provided by this review of the Fish Passage Barrier ISR and SIR. Fish Passage Barriers study in the Lower Susitna River must be closely coordinated with instream flow studies (Study 8.5), fish distribution and abundance studies (Study 9.6), fluvial geomorphology studies (Study 6.6), and tributary delta formation studies (Study 6.5). This coordination is critical because these other studies are tasked with providing the physical data necessary to evaluate fish passage. Therefore, the Fish Passage Study Team must identify specific sites where physical measurements and flow modeling results are necessary. Furthermore, consultation with the Services regarding fish passage criteria for each target species during each life stage must be finalized.

The study is being conducted as provided for in the approved study plan, but it is not evaluating projects effects on all effected environments if it stops at Talkeetna, when the Open Water Flow

Routing Model clearly shows effects below Talkeetna.

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9.14 Genetic Baseline Study for Selected Fish Species

ISR Review and Study Modifications

National Marine Fisheries Service (NMFS) comments and study modification requests are provided here prior to the completion of the Study's final report and as such do not reflect a final assessment of the project with respect to meeting the five objectives of the genetic baseline study. A full assessment of the project outcome and study conclusions by Alaska Energy Authority (AEA) will only be possible after the final report is complete. On behalf of AEA, the Alaska Department of Fish & Game (ADFG) Conservation Genetics Laboratory anticipates that the results of analyses and associated reporting will be completed in fall of 2016.

Study Objectives

The comments below consider the study progress with respect to the five study objectives as reported in the following documents:

1. 2014 Study Implementation Report of the Genetic Baseline Study for Selected Fish Species (from AEA).
2. Meeting Summary and Decision Points from the Fish Genetics Study 9.14 Technical Meeting, April 12, 2016 (from AEA).
3. Susitna-Watana NCI Chinook pre-consultation analysis November 2015.xlsx (spreadsheet from ADFG).
4. Susitna-Watana middle and upper Susitna River Chinook Salmon pre-consultation a….xlsx (spreadsheet from ADFG).
5. Initial Study Report (ISR) meeting presentation, March 22, 2016 (Power point file from ADFG)

The current year of study is not complete as a final analysis is in progress. Thus our comments focus primarily on results that are unlikely to change in the final analysis. We provide study modifications below which will improve the ability to meet the original objectives if implemented.

Review by Objective

Objective 1: *Develop a repository of genetic samples for target resident fish species captured within the lower, middle, and upper Susitna River drainage.*

Modification 1-1: Collect target numbers of resident fish species from the lower, middle and upper Susitna River drainage. Samples from 15 species of resident fish were collected opportunistically and archived at the ADFG Gene Conservation Laboratory. No analyses are planned. Sample sizes were not met; therefore we do not consider the Objective to have been met.

Objective 2: *Contribute to the development of genetic baselines for Chum, Coho, Pink, and Sockeye Salmon spawning in the middle and upper Susitna River drainage.*

Modification 2-1: Collect genetic samples of Sockeye Salmon from new locations including the Middle River to expand the genetic baseline for this study. Additional baseline samples were collected for the four species. The Chum Salmon, Coho Salmon, and Pink Salmon baselines benefited most from this effort as very few, if any, samples existed prior to the study. The Sockeye Salmon baseline for Cook Inlet was augmented during this study but these new samples were not from new locations.

Objective 3: *Characterize the genetic population structure of Chinook Salmon from upper Cook Inlet, with emphasis on spawning ground aggregates in the Middle and Upper Susitna River. As part of this objective, the following three hypotheses regarding Chinook Salmon in the Upper Susitna River will be tested:*

$H1_a$: Chinook Salmon above Devil's Canyon represent self-sustaining population(s) that are genetically isolated from Chinook Salmon aggregations below Devil's Canyon and potentially locally adapted;

$H1_b$: Chinook Salmon above Devil's Canyon represent successful reproduction in the Upper River but also experience a high level of introgression from Chinook Salmon aggregations below Devil's Canyon;

H2: Chinook Salmon above Devil's Canyon originate from aggregates below Devil's Canyon.

This objective has not been completed, so it has not been met. A detailed review is not possible at this time but NMFS provides the following comments and study modification requests. In some cases, our study modifications are simply to conduct the study per the study plan; we are providing these as study modifications to ensure that the Updated Study Determination clearly indicates what work must be completed for this study.

Modification 3-1: NMFS requests that the target number of genetic samples be collected and analyzed. The sample size targets for collections outside the Susitna River drainage were not met. The samples collected did augment existing archived collections. Population structure was evaluated for all upper Cook Inlet collections using 36 single nucleotide polymorphisms (SNP) loci (Document 3). Population structure will be further evaluated using an additional 47 SNP loci (Document 2). These additional loci may increase statistical support for the inferred population structure.

Modification 3-2: Additional samples of upper river spawning adults and rearing juveniles need to be collected and analyzed, because temporal replicates (inter-annual) are required to confirm the diversity and origin of the putative upper river populations. It will be impossible to test temporal stability of allele frequencies in the upper Susitna River collections because temporal replicates were not collected (Documents 1 and 4). This work needs to be completed. Because no further sampling is planned, it will not be possible to fully evaluate the three hypotheses. We do not agree that sampling is completed as the objective has not been met. Information regarding stock specific habitat usage is necessary to evaluate potential impacts of altered flow in the lower and middle river.

Modification 3-3: Provide the summary report for NMFS[SE1] and other stakeholder's review, including Federal Energy Regulatory Commission (FERC). Defer FERC's study determination for this study until after this report has been reviewed. The Decision Points for further analysis (Document 2, page 3) are appropriate given the samples in hand and the results to date. Further comments on the outcome of this objective should be provided when the final analyses are complete. AEA made two modifications to the study plan (Document 5):

Modification 3-4: The final report should discuss on both caudal fin clips and buccal swabs methods as sources of DNA and whether or not the change to buccal swabs could have influenced genotyping of juveniles. Caudal fin clips can adversely affect juvenile salmon, including causing mortality. Buccal swabs are not likely to be lethal but may not yield as much or as good a quality DNA. The investigators reported low DNA volumes and concentrations resulted in a lack of SNP data for some juvenile collections (Document 2).

Modification 3-5: Increase the number of markers to include 190 SNPs and 12 microsatellites for all Chinook Salmon captured in the Middle and Upper Susitna River. This is a reasonable modification to increase statistical power for identifying population structure. However[SE2], it is unlikely that all samples will be evaluated for 190 SNPs (Document 2 and see modification 1 above). It appears that most samples were successfully analyzed for 12 microsatellites.

Modification 3-6: Investigate sibling relationships for juvenile Chinook Salmon sampled upstream of Devils Canyon. Document what each sample set represents (whole stream, stream reach, etc.). These analyses can help estimate the number of spawning pairs in the collection and provide insight into how they may be included in the genetic baseline. Of the 363 total Chinook Salmon juvenile fish sampled from within or above Devils Canyon, the majority of the 2013 samples (189 fish) have been genotyped for both 13 microsatellite and 48 SNP markers. This is a very good data set to address sibling analysis and stock structure. For juveniles collected in 2014 (174 fish), non-lethal buccal swab sampling was conducted resulting in low concentrations of DNA.

Study Modification 3-7: Continue to non-lethally collect adult and juvenile samples and associated biological data (age, sex, length, habitat associations) from Chinook Salmon upstream of the proposed dam site for three collection years, each with a sufficient number of samples as determined from the requested power analysis (see Study Modification 4-2 below). This is necessary to increase the statistical power of the analysis and enable spatial and temporal analyses within individual streams.

Objective 4: *Examine the genetic variation among Chinook Salmon populations from the Susitna River drainage, with emphasis on Middle and Upper River populations, for mixed-stock analysis (MSA).*

This objective has not been completed. A detailed review is not possible in advance of the final annual report but the NMFS provides the following comments and study modifications which we are able to make now:

Modification 4-1: Temporal stability of allele frequencies in the Upper River collection must be determined. The preliminary analyses presented by ADFG at the April 12, 2016 meeting (see Documents 2 and 3) suggests it may not be possible to distinguish Middle River populations from mainstem populations for MSA. In addition, simulations to evaluate the baseline for MSA were not completed at the time of this review. Temporal stability of allele frequencies in Upper River collections has not been tested.

Modification 4-2: Conduct a power analysis to determine sample size requirements (adults and juveniles) for assessing genetic divergence of Chinook Salmon spawning above the proposed dam site. Results will continue to build upon preliminary genetic analyses outlining the population structure of Chinook Salmon in the Susitna River including samples from at or near the proposed dam site. Insufficient numbers of samples were collected to assess for this genetic divergence, which is very important for NMFS fish passage decision and for developing protection, mitigation and enhancements measures for any license for this project

Objective 5: *If sufficient genetic variation is found for MSA, estimate the annual percent of juvenile Chinook Salmon in selected Lower River habitats that originate in the Middle and Upper Susitna River in 2013 and 2014*.

Modification 5-1: NMFS recommends that Objective 5 be retained. AEA proposes a study modification to remove this objective (Document 2). Sampling juvenile Chinook Salmon in the lower Susitna River proved to be challenging and the number collected was insufficient for MSA. Nevertheless, it is important to determine if and to what extent Upper River fish use the Lower River habitats if the population structure analysis reveals self-sustaining populations in the Upper River. Therefore, we do not agree with the proposed modification to not estimate the annual percent of juvenile Chinook Salmon sampled in lower river habitats that originate in the Middle and Upper Susitna River. Additional sampling effort, or possibly alternative sampling methods (winter sampling, sampling environmental DNA) should be made to meet this important objective.

Modification 5-2: Conduct additional non-lethal collection and analysis of juvenile Chinook Salmon from the lower and middle Susitna to obtain sufficient numbers of Chinook salmon for MSA. NMFS recommends winter sampling with baited minnow traps in suitable Chinook Salmon overwintering habitat (upland sloughs, side channels with sufficient water velocity at the trap location, cover provided by woody debris, macrophytes or submerged shrubs and gravel substrate). NMFS has found this methodology successful in obtaining suitable numbers of juvenile Chinook Salmon provided that fall conditions allow immigration of juvenile Chinook Salmon into the habitat unit and winter flow events do not flush fish from the habitat (Davis and Davis 2015).

References

Davis, J.C. and G.A. Davis. 2015. Juvenile salmon winter habitat characteristics in large glacial rivers: 2014-2015. Final Report for the National Marine Fisheries Service. The Aquatic Restoration and Research Institute. Talkeetna, AK.
Download the report (PDF: 2.2MB)

9.16 Eulachon

ISR Review and Study Modification

Study Objectives

The objectives of the eulachon study, as specified in the Alaska Energy Authority's (AEA) Eulachon Study Plan, and identified as approved in the in the Federal Energy Regulatory Commission (FERC) study plan determination (April 1, 2013) was to collect baseline information regarding eulachon run timing, distribution, and habitat use in the Susitna River. The stated objectives of this baseline study are as follows:

1. Determine eulachon run timing and duration in the Susitna River in 2013 and 2014.
2. Identify and map eulachon spawning sites in the Susitna River.
3. Characterize eulachon spawning habitats.
4. Describe population characteristics of eulachon returning in 2013 and 2014.

The National Marine Fisheries Service (NMFS) has evaluated AEA's study plan and the work completed to date to determine if the objectives of the study has been met. For those objectives that were not met, recommendations and rationale for study modifications are addressed below.

Eulachon are important resources both as a valued fishery and as a critical prey item for Cook Inlet beluga whales. The eulachon study plan also indicates that the analysis of the Project's effects relies on the results of the fish distribution and abundance, fish and aquatics instream flow, water quality, geomorphology, and the ice studies.

NMFS's May 31, 2012 letter regarding study requests identified one objective specific to eulachon:

> *"…collect additional data to support efforts to determine the timing, distribution, and relative abundance of eulachon in the lower reach of the Susitna River."*

This objective was addressed by AEA's study objectives. However, AEA's objectives were not achieved in their study. In addition, in our May 31, 2012 letter we provided rationale as to why this was an essential objective. That rationale stated:

> *"An essential objective is to determine how potential changes in the natural system as a result of the proposed Project may affect the critical habitat and prey dynamics, and ultimately, impact the conservation or recovery of the Cook Inlet belugas whales and other marine mammals.*"

NMFS Study Modifications

Therefore, in order to meet AEA's study objectives NMFS requests that the study plan be modified to require at least two additional years of sequential data be collected throughout the entirety of the eulachon spawning runs to:

1. Determine eulachon run timing and duration in the Susitna River;
2. Identify and map eulachon spawning sites in the Susitna River;
3. Characterize eulachon spawning habitats;
4. Describe population characteristics of eulachon returning to the Susitna River watershed to spawn during consecutive years; including a quantification of the timing, distribution, and relative abundance of eulachon in the lower reach of the Susitna River during each spawning run.

Support for these recommendations is included below.

Objective 1: *Determine eulachon run timing and duration in the Susitna River in 2013 and 2014.*

The eulachon study plan indicates that eulachon studies will be conducted from approximately May 1 (or ice-out) through June 30 (or the end of the eulachon migration onto spawning grounds). The surveys were expected to use a combination of acoustic surveys, radio telemetry, and "standard" fish capture and habitat sampling methods to characterize the eulachon spawning migration. The studies did not start until sea ice was gone in the study area. Eulachon have been documented moving into the river prior to breakup (Vincent-Lang and Queral 1984). The study needs to start sampling before ice out or the study may miss much of the first spawning run.

Modification 1: Although working in water during ice breakup is difficult, it is possible to implement methods to enumerate each spawning run size in its entirety. Previous investigators have been able to document early under-ice runs (Vincent-Lang and Queral 1984). NMFS requests that at least two additional years of data be collected throughout the entirety of both eulachon spawning runs to document the phenology and size of each annual run.

Objective 2: *Identify and map eulachon spawning sites in the Susitna River*

Telemetry and mobile acoustic surveys were to be used to identify the distribution of spawning locations in the study area and to evaluate fish behavior on spawning sites. The proposed sample size was expected to be adequate. However, this study plan objective was not met. Although the methods are adequate, the studies did not start until sea ice was gone in the study area. The study needs to start sampling before ice out or the study may miss much of the early run. In addition, we have only one year of data; additional years of information are needed to adequately describe the distribution of eulachon spawning sites.

Modification 2: Recognizing that working in water during ice breakup is difficult; use methods to enumerate the run size while ice is still in the river. Previous investigators have been able to document early under ice runs (Vincent-Lang and Queral 1984). NMFS requests that at least two additional sequential years of data be collected throughout the entirety of the eulachon spawning run to better capture the variability in spawning distribution of eulachon.

Objective 3: *Characterize eulachon spawning habitats*

The study plan proposed to use a combination of active sampling and side scan sonar to identify the characteristics of the substrate where eulachon are spawning. Water quality parameters, including pH, water temperature, dissolved oxygen, specific conductance, and turbidity were to be collected at spawning sites and that the analyses would be used to evaluate the relationship between water temperature and run timing and to evaluate relationships between other water quality and hydrologic parameters and eulachon spawn timing. Water depth and water velocity were sampled at several locations at the spawning locations.

The study plan indicated that the data collected during the study was intended to be used to determine if there is a relationship between eulachon runs timing or abundance and flow, substrate, or water quality. The study assumes that predicted changes in water quality, substrate, geomorphology and flow from the other study components will be available to assess potential Project effects on eulachon. The study plan includes a figure (Figure 1 under Section 2: Cook Inlet Beluga whales) depicting the interdependent relationship between the eulachon study and the other Project studies. The adequacy of the inter-related studies in meeting their objectives as they relate to eulachon and Cook Inlet Beluga Whales is discussed in our review of Study 9.17.

The study plan indicated that two years of data would be collected. Only one partial year of data was collected, and that data missed the early portion of the run. NMFS requests that at least two additional sequential years of data be collected to better characterize eulachon spawning habitats.

Although the eulachon study plan indicates that the analysis of the Project effects rely on the results of the fish and aquatics instream flow, water quality, geomorphology, and the ice studies, no modelling of fish habitat, geomorphology or ice proposed in the lower river was completed. Therefore, inputs from those studies are not available. Water quality modelling (including temperature) is only proposed during the ice free months, so there will be no water quality modelling results available at the start of the eulachon run. In 2014, AEA proposed a different method for evaluating Project impacts on eulachon, but that study has not been implemented. Therefore, the information that the study plan assumed would be available to assess potential Project effects on eulachon is not available.

Modification 3: NMFS requests that at least two additional sequential years of data be collected throughout the entirety of the spawning run to evaluate and determine the characteristics of spawning habitat in the Susitna River. In addition, NMFS requests the following to suitably assess potential Project effects on eulachon:

- Extend the water quality investigation to include the lower river and the pre-breakup period.
- Extend the geomorphology modeling into the lower river.
- Extend the ice modeling to the lower river or find some other method to access likely Project effects on ice processes in the lower river.

- Explicitly identify how the assessment of Project effects on eulachon will be completed.

Further discussion regarding water quality, ice modeling and geomorphology is provided in Section 2 of this document.

Objective 4: *Describe population characteristics of eulachon returning in 2013 and 2014.*

This objective was not very clear. Our May 31, 2012 letter included an implied essential objective that included measuring the relative abundance of eulachon in the lower reach of the Susitna River. Absent some measure of baseline eulachon abundance over multiple spawning seasons, it is difficult to evaluate what population level effects the Project may have on this important species and essential feature of endangered Cook Inlet beluga whale critical habitat.

Therefore, because the study failed to capture the early portion of the early run during study year one, and no attempt was made to study population characteristics in year 2, the objective was not met. One partial year of data is inadequate for characterizing natural variability in population characteristics.

Modification 4: NMFS recognizes that that working in water during ice breakup is difficult. Nevertheless, AEA should implement methods to enumerate the run size while ice is still in the river. Previous investigators have been able to document early under ice runs (Vincent-Lang and Queral 1984). NMFS requests that at least two additional sequential years of data be collected throughout the entirety of the eulachon spawning runs to quantify the population characteristics of eulachon in this watershed, providing at least some indication of natural variability in run strength.

<u>Summary</u>

An essential objective is to determine how potential changes in the natural system as a result of the proposed Project may affect Cook Inlet beluga whale critical habitat and beluga whale prey dynamics, and how the Project may impact the conservation or recovery of the Cook Inlet Beluga whales and other marine mammals.

One partial year of data collection of eulachon run and habitat characteristics is an insufficient substitute for two full years of data collection, especially when two full years of data is the absolute minimum needed to gain any insight into inter-annual variability. We strongly recommend conducting at least two additional sequential years of this study spanning the entirety of the two annual eulachon spawning runs.

References

Vincent-Lang, D.S., and I Queral. 1984. Eulachon spawning in the lower Susitna River. Chapter 6 In: C.C. Estes, and D.S. Vincent-Lang, editors. Aquatic habitat and instream flow investigations, May-October 1983. Susitna Hydro Aquatic Studies Report No. 3 (Volume5). Alaska Department of Fish and Game, Achorage, Alaska. APA Document #1934.

9.17 Beluga Whales Study

ISR Review and Study Modifications

The Alaska Energy Authority (AEA) study plan, the revised AEA study plan, the Final AEA study plan, and all interim and final study reports related to the Cook Inlet beluga whale (CIBW) studies and the studies that were relied upon by the AEA study plan that addressed Project effects on physical processes in the river were reviewed to determine whether the National Marine Fisheries Service's (NMFS) objectives and the stated AEA objectives were met by a) the study plans and/or b) the studies completed to date. Where inadequacies in the study plans themselves or in the studies, as conducted, were identified, study modification requests were developed and detailed in the document.

The estuary and lower reaches of the Susitna River provide critical habitat for CIBW for both feeding and calving. These comments evaluate the AEA's study plans and the studies completed to date to determine whether the objectives of the studies have been met. For those objectives that were not met, study modifications have been requested to ensure that the Project studies adequately address potential Project impacts. The following provides a brief description of the analysis approach, a list of study objectives that were a) requested by NMFS and b) objectives specified in AEA's study plan. The following also provides a summary of whether the studies completed to date met either the NMFS or AEA's study plan objectives. For those objectives that were not met, NMFS, as discussed below, is recommending study modifications.

Study Objectives

The objectives stated in NMFS's May 31, 2012 letter regarding study requests were as follows:

- Establish pre-construction baseline habitat data for the endangered CIBW, other marine mammals, and the status of essential features or primary constituent elements of designated CIBW critical habitat in the Susitna River Delta.
- Determine how potential changes in the natural system as a result of the proposed Project may affect CIBW critical habitat and prey dynamics, and ultimately, impact the conservation or recovery of the CIBW and other marine mammals.

AEA's stated study objectives included:

1. Document CIBWs and other marine mammals in the Susitna River delta, focusing on CIBW distribution and upstream extent.
2. Document CIBW group size, group composition, and behavior within the Susitna River delta.
3. Develop a model to describe the relationships between river flows, water surface elevation, and CIBW foraging habitats in the Susitna River.

In addition to the above stated objectives, AEA's study plan identified several studies which address the physical and biological effects of the Project that will inform the assessment of Project effects on CIBW (objective 3, above) (Figure 1). These include:

1. The 9.6 Fish Distribution and Abundance Study which addresses Project effects on fish populations and subsequently, effects on prey availability for the whales;
2. The 9.7 Salmon Escapement Study which addresses the numbers of fish escaping into the Susitna River which are important prey species for CIBW;
3. The 8.5 Instream Flow Study which addresses habitat associations of salmon in the Susitna River and the likely Project effects on salmon habitat and subsequently salmon production;
4. All three Water Quality studies (5.5, 5.6, and 5.7) which address Project effects on temperature, dissolved oxygen, suspended sediment, and mercury in the water column (which affect both salmon production and mercury exposure on CIBW);
5. The 6.5 Geomorphology Study and the 6.6 Fluvial Geomorphology Modeling Study addresses Project effects on river geomorphology, which may affect salmon, CIBW, and eulachon habitat, and;
6. The 7.6 Ice Processes Study which addresses Project effects on ice in the river which may affect salmon egg incubation, and subsequently CIBW prey abundance as well as access to the river by eulachon and CIBW.

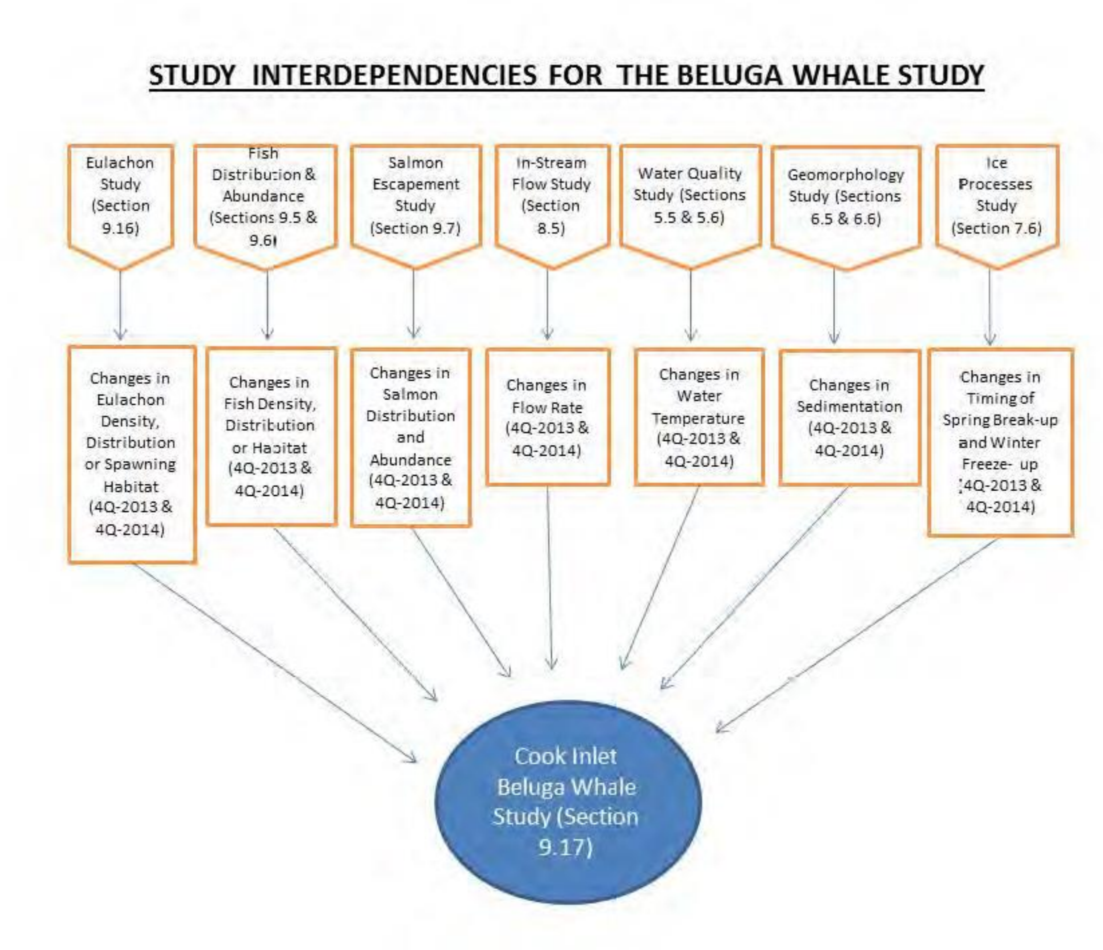
The 9.16 Eulachon Study addresses the distribution, abundance, and habitat associations of eulachon in the Susitna River. The eulachon study will also be used to support the assessment of Project effects on prey availability for CIBW. Collectively, these studies were designed to address the potential Project impacts on the five primary constituent elements (PCEs) of CIBW critical habitat. The five PCEs of CIBW critical habitat; elements that are essential to the conservation of the species include:

1. Intertidal and subtidal waters of Cook Inlet with depths <30 feet below MLLW (mean lower low water) and within 5 miles of high- and medium-flow anadromous fish streams.
2. Primary prey species are four species of Pacific salmon (Chinook, Sockeye, Chum, and Coho), Pacific Eulachon, Pacific Cod, Walleye Pollock, Saffron Cod, and Yellowfin Sole.
3. Waters free of toxins or other agents of a type and amount harmful to CIBWs.
4. Unrestricted passage within or between the critical habitat areas.
5. Waters with in-water noise below levels that might result in the abandonment of critical habitat areas by CIBWs.

In addition to the CIBW study, the interdisciplinary studies addressed here focus on study objectives pertinent to the evaluation of potential Project effects on CIBW and their PCEs.

Achieving the objectives of the CIBW study relies upon the success of the inter-related studies in achieving their respective goals and objectives. The inter-related studies are therefore discussed below prior to the discussion of the CIBW studies:

Figure 1: CIBW Study interdependencies (from the AEA Final Study Plan).



NMFS Study Modifications

1. Complete the work associated with baseline water quality study and water quality modeling study (Study 5.5-Modification 3-1, Study 5.6 –Global modification).
2. Add a mercury bioaccumulation assessment to *the mercury assessment and potential for bioaccumulation study* which addresses the effects of downstream transport of mercury on biota, including CIBW (Study 5.7, Modification 10-1).
3. For the 6.5 Geomorphology Study and 6.6 Fluvial Modeling Study, NMFS requests that:
4. Increase sampling in the lower river to adequately characterize sediment supply and transport in each of the updated reaches in the lower river (Study 6.5, Modification 2-1);
    a. Provide several operational scenarios, and determine the range of likely flow release quantities and patterns expected for reservoir operations with the Project in place, and redo analyses of Project effects on sediment supply and transport as needed to reflect the range of likely operations (Study 6.6, Modification G-1);

   b. Modeling of channel morphology be extended to the mouth of the river and the tidal hydrodynamic modelling be completed under a range of likely reservoir operation scenarios and including an evaluation of changes in ice formation be completed for the lower 29.9 miles of the Susitna River (Study 6.6, Modification 2-4);
   c. For the 7.6 Ice Processes study, NMFS recommends that modelling of ice build-up and operational effects on breakup in the Lower River be conducted (Study 7.6, Modification 6-1).
5. For the 8.5 Instream Flow Study, NMFS recommends that the approach used to develop the Habitat Suitability Index (HSI) curves be modified using a more conventional approach that will allow for the assessment of the effects of change in temperature on salmon production. (Study 8.5, Modification 4-3).
6. For the 9.9 Characterization of Aquatic Habitats, NMFS recommends:
   a. Extending sampling into the Lower River using randomly selected sites, based on a stratified design (Study 9.9, Modification 12).
   b. Refining the Aquatic Habitat Maps for approximately the lowest 50 miles of the Susitna River. For this same lowest 50 miles NMFS recommends the geomorphic reaches be redefined to better represent the larger scale geomorphic processes in the river.
7. For the 9.17 CIBW study plan, NMFS requests:
   a. Conducting additional surveys to document the in-river habitats used by CIBW following a study plan developed in coordination with NMFS.
   b. Using an analytical approach to evaluating Project effects on CIBW and their PCEs be developed in coordination with NMFS, be approved by NMFS, and implemented by AEA.
8. NMFS recommends that a sensitivity analysis be conducted to determine to what extent study results that are used as model input data affect output of those models, identifying those studies that may have pronounced effects upon model output, but for which there is considerable uncertainty surrounding model input parameters. Studies producing results with high levels of uncertainty and that have a high degree of influence over model output should be refined and repeated to reduce uncertainty of model input parameters, especially those parameters that may influence projected effects upon endangered CIBW, CIBW critical habitat and CIBW prey. This modification will be best accomplished in a New Study Request for Model Integration which is included in a separate enclosure.
9. NMFS recommends that most of the aquatic studies be extended downstream. This has been articulated in modifications in many other studies.
10. NMFS recommends that an approach for addressing potential Project effects on eulachon and CIBW be developed, implemented, and revised as needed, based on NMFS's review (See Additional Modification at the end).
11. All studies with potential to observe belugas should record incidental sightings information; this effort should not be limited to the eulachon studies. NMFS recommends developing and distributing CIBW observation/data collection sheets to all lower Susitna River in-stream and land-based investigators who may observe CIBWs in the river itself, as well as in the river delta area.

Review by Objectives

Baseline Water Quality Study (5.5) and Water Quality Modelling Study (5.6)

AEA's objectives for the baseline water quality study and water quality modelling study are:

- Implement an appropriate reservoir and river water temperature model for use with past and current monitoring data.
- Using the data developed in the Baseline Water Quality Study, model water conditions in the proposed Susitna-Watana Reservoir, including (but not limited to) temperature, dissolved oxygen (DO), suspended sediment and turbidity, chlorophyll-a, nutrients, ice, and metals.
- Model water quality conditions in the Susitna River downstream of the proposed site of the Susitna-Watana Dam, including (but not limited to) temperature, suspended sediment and turbidity, and ice processes (in coordination with the Ice Processes Study).

The study area for water quality monitoring originally included the Susitna River from Project River Mile (PRM) 15.1 to PRM 233.4, and select tributaries, but was modified in 2014 to include only those portions of the river upstream of PRM 29.9.

Evaluation and Study Modifications

From the standpoint of the CIBW study, the Baseline Water Quality Study and the Water Quality Monitoring Study are of interest as it affects salmon and eulachon survival and production (CIBW prey). The Project could affect the parameters measured by the study as far downstream as CIBW critical habitat or riverine habitat seasonally occupied by CIBW; therefore, indirect effects on CIBW are anticipated. NMFS's study objectives related to Project effects on prey abundance are pertinent for this study.

Objective 1: *Implement an appropriate reservoir and river water temperature model for use with past and current monitoring data*

Generally, this study is well conceived. Initial difficulties with quality control seem to have been resolved. The study plan includes sampling of additional environmental media for metals only if exceedances are observed in sampled water, sediment, or fish tissue. The addition of sampling zooplankton is encouraged as concentrations of metals in zooplankton can be transported to the lower river through drift of these organisms. Establishing a baseline metals concentrations in zooplankton will be an important element in the calibration and evaluation of bioaccumulation modelling results, and should be incorporated into the upcoming field sampling program.

Objective 2: *Using the data developed in the Baseline Water Quality Study, model water conditions in the proposed Susitna-Watana Reservoir, including (but not limited to) temperature, dissolved oxygen (DO), suspended sediment and turbidity, chlorophyll-a, nutrients, ice, and metals*

The water quality model has been developed for riverine conditions (existing), reservoir conditions (future), and riverine conditions (future). The model calibration results have been presented comparing the observed and predicted river temperature. The riverine hydrodynamic model has not yet been validated. No documentation statistics have been provided regarding model calibration.

The modelling to simulate DO, fine suspended sediment and turbidity, chlorophyll-a, nutrients, ice, and metals is incomplete for the existing riverine model, the future riverine model, and the future reservoir model. Therefore, effects of dam-induced changes of these parameters on habitats used by CIBW and their prey remain unknown. It is not clear how the Water Quality Modelling study fits into other Project studies.

Objective 3: *Model water quality conditions in the Susitna River downstream of the proposed site of the Susitna-Watana Dam, including (but not limited to) temperature, suspended sediment and turbidity, and ice processes (in coordination with the Ice Processes Study)*

The water quality model has been developed for riverine conditions (existing), reservoir conditions (future), and riverine conditions (future). The model calibration results have been presented comparing the observed and predicted river temperature. The riverine hydrodynamic model has not yet been validated. No documentation statistics have been provided regarding model calibration.

The modelling to simulate DO, fine suspended sediment and turbidity, chlorophyll-a, nutrients, ice, and metals is incomplete for the existing riverine model, the future riverine model, and the future reservoir model. It is not clear how the Water Quality Modelling study fits into other Project studies.

Modification 1: NMFS recommends completing the work associated with baseline water quality study and water quality modeling study. This is described and justified in Study 5.5-Modification 3-1, and Study 5.6 –Global Modification.

Mercury Assessment and Potential for Bioaccumulation (5.7)

The general objectives of the Study were to quantify current mercury concentrations in the proposed inundation zone (behind future reservoir), estimate potential changes to mercury concentrations post-impoundment, and the impacts these changes will have on the ecosystem.

Evaluation and Study Modification

From the standpoint of the CIBW PCEs, mercury generated within the reservoir and transported into waters downstream of the proposed dam has the potential to bioaccumulate in zooplankton, fish, and CIBW. The water quality parameter that has the greatest potential to directly affect CIBW is mercury concentration. Modelling of mercury in the reservoir is incomplete. As currently planned, the studies will not address potential exposure of CIBW to mercury.

A downstream component should be added to the study. This will require additional geological study to provide information needed to model sediment/mercury interactions. It will also require addressing exposure to, and bioaccumulation of, mercury in zooplankton, salmon, and eulachon. Modeling accumulation of mercury in predatory species, including CIBW, will likely rely on existing literature relating concentration in water and prey to accumulation in higher trophic level species.

Modification 2: NMFS recommends adding a mercury bioaccumulation study which addresses the effects of downstream transport of mercury on biota, including CIBW. This modification is described and justified in Study 5.7, Modification 10-1.

Geomorphology Study (6.5)

The goals of the study are to determine how the river system functions under existing conditions, determine how the current system forms and maintains a range of aquatic and channel margin habitats, identify the magnitudes of changes in the controlling variables and how these will affect existing channel morphology in the identified reaches downstream of the dam and in the areas upstream of the dam affected by the reservoir, and, in an integrated effort with the Fluvial Geomorphology Modelling Study (6.6), determine the likely changes to existing habitats through time and space resulting from the construction and operation of the proposed Project.

The study area for the Geomorphology Study is the Susitna River from its confluence with the Maclaren River (PRM 260) downstream to the mouth at Cook Inlet (PRM 0).

Evaluation and Study Modification Requests

From the standpoint of the CIBW study, objectives 5, 8, 9, and 10 (listed above) are important objectives related to the evaluation of potential Project effects on CIBW prey, but do not address the physical habitat occupied by CIBW. The other objectives for the Geomorphology Study directly address current CIBW habitat and potential Project effects on that habitat. NMFS's study objectives related to Project effects on current and future habitat and conditions and prey abundance (PCEs) are partially addressed by this study. The geomorphology objectives are addressed below.

Objective 1: *Geomorphically characterize the Project-affected river channels and floodplain*

Based on a cursory review of the channel structure, tributary inputs, and changes in stream gradient, the Middle and Lower River should have had more geomorphic reaches. For instance, reach breaks should always be placed at tributary junctions since tributaries change water and sediment inputs; however, there are several reaches that contain tributary junctions within the reaches. Reach breaks should be placed where significant changes in channel gradient occurs since gradient affects sediment transport. However, several of the currently defined reaches contain a wide range of channel gradients. Reach breaks should also be placed at locations where the channel changes from a confined single channel to a complex braided channel since sediment transport processes are affected by channel morphology, however, several of the defined reaches contain both single channel and braided channel sections. The lumping of different geomorphic river types into one geomorphic reach will tend to dampen or average the modelled expected effects of the Project. Generally, the reaches in the Lower River will be affected more than the Middle River by the selected geomorphic reach breaks.

Objective 2: *Collect sediment transport data to supplement historical data to support the characterization of Susitna River sediment supply and transport*

The data set collected by AEA for the Middle River is likely adequate to support analyses of the potential Project effects on channel geomorphology. Additional data may be required to adequately characterize sediment supply and transport in the lower river.

Modification 3a: NMFS recommends increasing sampling in the lower river to adequately characterize sediment supply and transport in each of the updated reaches (see objective 1) in the lower river. This is described and justified in Study 6.5, Modification 2-1.

Objective 3: *Determine sediment supply and transport in Middle and Lower Susitna River Segments*

Under this study objective, sediment inputs were to be estimated and the size of material that is mobilized monthly with and without the Project was estimated using USGS empirical sediment rating curves, incipient motion calculations. Notable is that the recent geomorphology reports indicate that the base flows with the Project in place are unknown since reservoir operations have not yet been determined. The assumed reservoir operations used in the modelling was the Maximum Load Following Operational Scenario 1B (Max LF OS-1b). As a result, the expected effects evaluated to date may or may not be reflective of actual Project effects. Therefore, the effects on sediment transport in the lower river (affecting CIBW) and the middle river (affecting salmon production, CIBW prey) remains unknown.

Modification 3b: NMFS recommends determining the range of likely flow release quantities and patterns expected for reservoir operations with the Project in place, and redoing analyses of Project effects on sediment supply and transport as needed to reflect the range of likely operations. This modification is described and justified in Study 6.6, Modification G-1.

Objective 4: *Assess geomorphic stability/change in the Middle and Lower Susitna River Segments*

Under this study objective, current and historical river patterns were compared. We have no comments related to belugas on this objective.

Objective 5: *Characterize the surface area versus flow relationships for riverine macrohabitat types (1980s main channel, side channel, side sloughs, upland sloughs, tributaries and tributary mouths) over a range of flows in the Middle Susitna River Segment*

Per the updated study report released in November 2015, this task will not be completed. The data that would have been provided has instead been developed by other study components and is likely more robust. We have no comments related to beluga on this objective.

Objective 6: *Conduct a reconnaissance-level geomorphic assessment of potential Project effects on the Lower and Middle Susitna River Segments considering Project-related changes to stream flow and sediment supply and a conceptual framework for geomorphic reach response*

The technical memorandum *Decision Point on Fluvial Geomorphology Modelling of the Susitna River below PRM 29.9* (Tetra Tech 2014), filed September 26, 2014 technical memorandum describes the decision of whether to extend the downstream limit of the 1-D bed evolution model below Susitna Station at PRM 29.9. The document indicates that the primary reason to consider extending the fluvial geomorphology modelling below PRM 29.9 is to assist in describing the relationship between river flows, water surface elevation and CIBW foraging habitat in the Susitna River. The metrics that were included in the evaluation were hydrology, sediment transport, channel morphology, and hydraulic conditions (changes in channel flow velocity and depths). The changes in these variables between existing conditions (pre-Project) and the Maximum Load Following Operational Scenario 1B (Max LF OS-1b) were characterized within the context of the natural variability under existing conditions. The analysis was not based on any modelling, but rather extended the patterns documented upstream of PRM 29.9 to the area downstream of PRM 29.9. AEA assumed that small changes due to Project operations relative to the range of natural variability would be considered minor changes that would not warrant the extension of the 1-D fluvial geomorphology modelling downstream.

The predicted Project-induced changes during the open water flow period are generally reduced flows, sediment transport, water surface elevations, flow depth, and velocities. The differences are the largest in the early portion of the open water season when CIBW are likely to be present in the area. The aggradation patterns of the Lower River are predicted to be maintained, but at a slightly reduced rate. The Susitna River channel is also expected to narrow slightly due to changes in channel forming flows. AEA concluded that the reductions in the variables are predominantly within the range of natural variability, both spatially and temporally, and also concluded that given this, the extension of the modelling downstream is not warranted. Because the expected changes resulting from Project operations will be very small compared to the large range of natural variability in the tidal zone, AEA is also recommending that no tidal hydrodynamic modelling be conducted in the lowest portions of the Susitna River.

Most of the analysis is based on the results of the 1-D Bed Evolution Model results. The hydrology analysis indicates that the Project will cause average flows to decrease by 5-13 percent at Susitna Station. The largest of these changes are for the smaller flows. Since the average annual flow (roughly the 2-year flow return interval) typically drives channel morphology, a 13 percent decrease is not insignificant and can potentially result in increased sediment deposition and shallower channels. The expected reduction in width at Susitna Station is less than 6 percent (assumed to be the square root of the change in flow). The river at Susitna Station is about 3600 feet wide. This would be equivalent to roughly a 216 foot reduction in overall width. This estimated change in channel width is for the width of the entire river and is based only on a rule-of-thumb analysis.

Project operations under the Maximum Load Following Operations Scenario OS-1b produce a 10 to 15 percent reduction in the sediment load (sand and larger materials) transported past Susitna Station. The bed elevation model suggests that the river would continue to aggregate sediment in the lower river, but at a slower rate (23 percent reduction in sediment deposition at Susitna Station).

AEA argued that the predicted changes are within the range of natural variation and therefore should not be considered significant. The reduction in open water season flow, width, and sediment transport will effectively shift the range of natural variability. The conditions with the Project in place will lie outside of the range of natural conditions for some percentage of time (generally in the range of 6 to 10 percent of the time, depending on the variable). More importantly, the channel morphology tends to respond to the average flows (1.5 to 5 year return intervals), so changes in flow and sediment deposition will be expected to result in changes in river morphology. Since no modelling has been completed for this section of the river, the direction of change is difficult to predict.

In conclusion, the AEA decision to NOT model the lower river downstream of PRM 29.9 cannot be supported because:

- Predicted changes at PRM 29.9 in stream flow, water depth, and channel width are not insignificant and could potentially have substantial effects on channel morphology in the lower river.
- The analysis did not address increased winter flows and the possible effects of those flows on channel morphology
- The analysis did not include an evaluation of the effects of changed flows and water depth on ice conditions and subsequent impacts on channel morphology
- The predicted change in mid-winter flow and channel width does not appear to be within the normal range of variability
- The predicted decrease in flow during the summer will cause changes in channel morphology
- The largest predicted changes are expected to occur during the early open water season when CIBW are likely to be present.

Modification 3c: NMFS recommends that the modeling of channel morphology be extended to the mouth of the river and that tidal hydrodynamic modeling be completed under a range of likely reservoir operation scenarios and including an evaluation of changes in ice formation be completed for the lower 29.9 miles of the Susitna River. This is described and justified in Study 6.6, Modification 2-4.

Objective 6 through 10: We have no comments related to beluga whales on the studies conducted to address objectives 6-10.

Objective 11: *Integration with the Fluvial Geomorphology Modeling Study to develop estimates of Project effects on the creation and maintenance of the geomorphic features that comprise important aquatic and riparian macrohabitats and other key habitat indicators, with particular focus on side channels, side sloughs, and upland sloughs.*

The 2014-2015 Study Implementation Report for the Geomorphology Study released in November, 2915 indicates that this task is ongoing. The conclusions and interim results presented in that report are based on the poorly defined geomorphic reaches and would likely change if better reach breaks were defined. The use of proper reach breaks is particularly important to the assessment of likely Project effects on salmon spawning and rearing habitat, since those changes are likely to occur on a smaller scale. Since geomorphic modelling downstream of the RM 29.9 and ice processes modeling in the entire lower river have not been completed (and are currently not proposed), the likely Project effects on the lower river have not been suitably addressed.

<u>Ice Processes Study (Study 7.6) Objectives Evaluation And Study Modifications</u>

The Ice Processes in the Susitna River Study (Study 7.6) is intended to further the understanding of natural ice processes in the Susitna River and provide a method to model/predict pre-Project and post-Project ice processes in the Susitna River. The study also in intended to provide ice processes input data for other resource studies with winter components (e.g., Fluvial Geomorphology Model [Study 6.6], Instream Flow Studies [Studies 8.5-8.6], Instream Flow Riparian [ISR Study 8.6], and Groundwater Study [Study 7.5]).

The river ice processes study relies upon the outputs of the Water Quality Modelling Study (Study 5.6).

The increased winter flows could potentially affect where ice forms in the Lower River and may also affect ice thickness and the rate of ice melt in spring. Changes in flow regime and resulting ice formation has the potential to change instream flow and geomorphology of the river (rerouting flows) in all reaches below the dam with potential impacts to habitat and fish production. Changes in ice processes have the potential to affect access to the river by CIBW and early runs of eulachon and may also affect the geomorphology of the Lower River. Therefore, the ice processes study is an important component required to address potential Project effects on CIBW PCEs.

Objective 1: *Document the timing, progression, and physical processes of freeze-up and break-up during 2012–2014 between tidewater and the Oshetna River, using historical data, aerial reconnaissance, stationary time-lapse cameras, and physical evidence.*

We have no comment related to belugas on the studies completed to address this objective.

Objective 2*: Determine the potential effect of various Project operational scenarios on ice processes downstream of Watana Dam using modelling and analytical methods.*

No modelling of ice processes in the lower river has been conducted and none were planned. Therefore, the expected Project effects on ice and subsequent impacts on geomorphology and CIBW and eulachon habitat remain unknown. AEA has assumed that there will be negligible effect on ice formation. AEA's geomorphology assessment, however, has identified substantial potential changes in stream flow, channel width, and depth during the upon water season. The largest changes during the open water period are predicted to occur around and immediately following the ice break period. The increased winter flows have not been addressed and are also likely to affect ice processes.

Modification 4a: NMFS recommends modeling of ice build-up in the Lower River.

Although no model exists that can adequately incorporate braided channels, the River 1D or River 2D Models could be used in selected channels where CIBW are most often observed. This would require collection of flow data in selected channels and upstream of those channels to determine the proportion of the total Susitna River flow that is captured by the modelled channel. Therefore, additional flow measurements, as well as additional cross-sections, would likely be required. For the purposes of determining the proportion of the flow present in the selected channels, spot measurements taken at three or more water elevations during winter would provide sufficient information to support the development of a rating curve that predicts the relative flow within the modelled channel.

It is helpful that the assessment of geomorphic processes has been extended down to PRM 29.9 (Susitna Station). The inclusion of intertidal areas that are of primary interest for the assessment of potential impacts on CIBW adds a level of complexity, however, it will be important to consider these effects in the context of an Endangered Species Act consultation. We recommend that the study be extended of the downstream limit of the study to PRM 0 and that the study includes intertidal areas used by CIBW. We suggest using a simplified modeling approach, for example a simplified Environment Fluid Dynamics Code (EFDC) Model can be developed for the Lower River, without developing a suite of other models. The input to the model could be closely coordinated with the Open Flow Routing Model (HEC-RAS, version 2) and the 1-D Sediment (Bed Evolution) Model (currently in development). Even the simplified EFDC Model would be able to assess changes in water depth, flow velocity, DO, and selected water quality variables due to implementation of the OS-1 Operating Scenario at the Susitna Dam.

This modification is further described and justified in Study 7.6 modification 6-1.

<u>Fish and Aquatics Instream Flow (Study 8.5) Evaluation of Objectives and Study Modifications</u>

The Instream Flow Study is designed to characterize the existing, unregulated flow regime and the relationship of instream flow to riparian and aquatic habitats under alternative operational scenarios. The instream flow framework is designed to integrate riverine processes, including geomorphology, ice processes, water quality, and groundwater-surface water interactions to quantify changes in indicators used to measure the integrity of aquatic resources. This study is the primary study utilized to estimate Project effects on salmon (CIBW prey).

Objective 1: *Map the current aquatic habitat in main channel and off-channel habitats of the Susitna River affected by Project operations*

We have no comments related to belugas on this objective.

Objective 2: Select study areas and sampling procedures to collect data and information that can be used to characterize, quantify, and model mainstem and lateral Susitna River habitat types at different scales.

Objective 3 and 5 through 8: Work on these objectives is underway but not complete. Our sense is that the detailed approach has not been thought through thoroughly and we question whether the data being collected will be adequate to support a valid analysis of potential Project effects on fish habitat.

Objective 4: Develop site-specific Habitat Suitability Criteria and Habitat Suitability Indices (HSI)

Temperature is being monitored and modeled for the reservoir and downstream waters. We have no concerns regarding the ability to model temperature with the Project in place. We do have some very significant concerns regarding the evaluation of the effects of temperature changes on salmon habitat (and ultimately salmon production). At present, AEA is developing HSI curves that reflect the habitat preferences of salmonids. They are using a multivariate polynomial curve fitting process to describe the habitat associations. The preliminary curves presented in the ISR not only do not make biological sense, they do not include temperature; temperature was not found to be significantly correlated to fish abundance. Temperature is predicted to increase during winter with the Project in place. This will result in early emergence of fish and will also affect the production of zooplankton on which fish feed. The change in temperature will also affect growth and possibly timing of out migration of smolts. Therefore, it is critical that temperature be incorporated into the assessment of suitable habitat with and without the Project.

Modification 5: NMFS recommends that the approach used to develop the HSI curves be modified using a more conventional approach that will allow for the assessment of the effects of change in temperature on salmon production. (This is similar to Study 8.5, Modification 4.3). Where there is disagreement the modifications requested in Study 8.5 trump the mods for 8.5 presented here.

Fish Distribution and Abundance In The Middle and Lower Susitna River (Study 9.6) Evaluation of Objective and Study Modification

The overarching goal of this study is to characterize the current distributions, relative abundances, run timings, and life histories of all resident and non-salmon anadromous species as well as freshwater rearing life stages of anadromous salmonids (fry and juveniles) in the Middle and Lower Susitna River. The study is not proposed to be used to assess potential effects of the Project on fish abundance. Therefore, we have no comment on this study as it relates to CIBW.

Characterization of Aquatic Habitats (Study 9.9) Study Objectives Evaluation and Modification Requests

Changes in habitat quality and quantity generated by the proposed Project may affect fish habitat and, in turn, fish productivity in the river. Changes in fish productivity may affect prey abundance available to CIBW in or near the Susitna River.

Objective 1: *Characterize and map Upper River tributary and lake habitats*

The fish species present upstream of the proposed Watana Dam site are freshwater species that generally do not move into CIBW habitats. Therefore, we have no comment regarding this objective as it pertains to CIBW.

Objective 2: *Characterize and map Middle River tributary and lake habitats*

There are minor issues related to the study of the Middle river, however, we have no significant comments on the studies conducted to meet this objective, as it relates to CIBW.

Objective 3: *Characterize and map Lower River tributary and lake habitats*

The study goals related to the Lower River were not addressed. The river was divided into geomorphic/hydrologic reaches and aerial photos were used to try to identify the macrohabitat and mesohabitat types in the Lower River. The method was not found to be a practical method for habitat mapping the Lower River. Habitat mapping in the Lower River is limited to the data collected by the Geomorphology Study (sparse data in side channels, sloughs and shallow water areas along shore). This study did not collect any data in the Lower River; therefore the goal of the study relative to the Lower River was not met. The ISR indicated that a classification system for the Lower River segment is still in development.

It is unclear how the data collected and reported will be used to assess Project effects. Based on the discussion during the "Proof-of-Concept" meeting, it would appear AEA's consultants are not clear on that either. Somehow, this data feeds into the instream flow analysis; but the Instream Flow Study also collects habitat data, but at a much more refined scale. Since we are not sure how this data will be used, we are uncertain whether the quality of the data (or lack thereof) will affect the ability to predict Project effects on CIBW or their prey.

Modification 6a: NMFS recommends extending sampling into the Lower River using randomly selected sites, preferably based on a stratified design. This modification is described and justified in Study 9.9, Modification 12)

Modification 6b: NMFS recommends refining the Aquatic Habitat Maps for approximately the lowest 50 miles of the Susitna River.

Aquatic habitat maps were focused on the Middle and Upper River and a few habitats were defined below Talkeetna. For it to be useful for predicting effects on beluga whales, the lowest 50 miles with sandy bottoms need more thought and definition. This modification (6a) does not comment on the work done above mile 50. The modification listed in NMFS review of 9.9 applies above mile 50.

The study was not conducted as provided for in the approved study plan because Habitat in the lowest reach was not mapped to an appropriate level of detail.

<u>Cook Inlet Beluga Whales (Study 9.17) Study Objectives Evaluation and Modification Requests</u>

The overarching goals of the CIBW studies were described at the start of Section 2 of this document. The goals and objectives specified by NMFS pertain to the ability to assess potential Project effects on CIBW and their PCEs. The objectives that were specific to the CIBW study included the following:

1. Document CIBWs and other marine mammals in the Susitna River delta, focusing on CIBW distribution and upstream extent.
2. Document CIBW group size, group composition, and behavior within the Susitna River delta.
3. Develop a model to describe the relationships between river flows, water surface elevation, and CIBW foraging habitats in the Susitna River.

Objective 1: Document CIBWs and other marine mammals in the Susitna River delta, focusing on CIBW distribution and upstream extent.

Efforts have been made, with varying success, to complete this objective. Survey data collected by NOAA has also been used to address this objective.

Modification 7a: NMFS recommends conducting additional surveys to document the in-river habitats used by CIBW following a study plan developed in coordination with NMFS.

Beluga whale spend a significant amount of time foraging for Eulachon and other prey in the Susitna Delta and up past the Yentna confluence. Currently we do not know if the beluga whales favor particular areas. We also do not know if there is a minimum depth or habitat characteristic that confines where they go. Further surveys are needed to document the habitats utilized in the river. We request that a study plan be developed in conjunction with NOAA to address this need.

The study was not conducted as provided for in the approved study plan because the study of beluga whale distribution in the river was not comprehensive.

Objective 2: *Document CIBW group size, group composition, and behavior within the Susitna River delta.*

Efforts have been made, with varying success, to complete this objective. Survey data collected by NOAA has also been used to address this objective.

Objective 3: *Develop a model to describe the relationships between river flows, water surface elevation, and CIBW foraging habitats in the Susitna River.*

The water surface elevation model was described in the preliminary and revised study plans and has not been changed in the final study plan. We understand that the water surface elevation model will not be developed as was originally planned. An approach to evaluating potential Project effects on CIBW and their PCEs has not yet been developed.

Modification 7b: NMFS recommends using an analytical approach to evaluating Project effects on CIBW and their PCEs be developed in coordination with NMFS, be approved by NMFS, and implemented by AEA.

The study was not conducted as provided in the approved study plan because the relationship between discharge and beluga foraging was not described.

<u>Overall Conclusion Regarding NMFS's Objectives and Modification Requests</u>

This discussion is broken down into three components, addressing the ability of the overall study package to address potential Project impacts on: 1) the physical environment utilized by CIBW, 2) the prey consumed by CIBW, and 3) water quality issues potentially impacts the CIBW.

One overarching comment we have on most of the studies is that the details regarding the modelling approaches generally have not been well documented. It is often difficult to determine which parameters will be used as input data and the expected source of those inputs are also not well documented. This makes it difficult to track how weaknesses in data collected by one study will affect the outcomes of other studies dependent upon that data. In this document, we have documented a couple of cases where we have identified issues that are likely to affect other study results, but we have not conducted a comprehensive evaluation of the inputs and outputs for the various models. We do, however, recommend that such an effort be conducted.

Physical Environment

Regarding the potential Project effects on the physical environment occupied by CIBW, the primary issues of concern are potential effects on stream flow, ice processes (influenced by stream flow and geomorphology), and geomorphology (influenced by both stream flow and ice processes).

Stream Flow: We do not know whether the expected increase in flows in winter and decrease in flow in summer will affect CIBW congregation patterns at the mouth of the Susitna River. No test of the likely effects of changes in stream flow on CIBW congregation patterns is included in the study plans. The correlation between stream flow and CIBW congregation has only recently been discovered (Ezer et al. 2013). It may be informative to evaluate the range of stream flows that have occurred naturally during the period that CIBW congregate at the mouth of the Susitna River and compare that range to the expected stream flows with the Project in place.

Geomorphology: The assessment of geomorphic processes extends down to PRM 29.9 (Susitna Station). The inclusion of intertidal areas that are of primary interest for the assessment of potential impacts on CIBW is not currently under consideration. We recommend that the geomorphology study be extended to the downstream limit of the study to PRM 0 and that the study includes intertidal areas used by CIBW. We suggest using a simplified modeling approach, for example a simplified EFDC Model can be developed for the Lower River, without developing a suite of other models. The input to the model could be closely coordinated with the Open Flow Routing Model (HEC-RAS, version 2) and the 1-D Sediment (Bed Evolution) Model (currently in development). The simplified EFDC model would be able to assess changes in water depth, flow velocity, DO, and selected water quality variables due to implementation of the OS-1b Operating Scenario at the Susitna Dam and would support the extension of the ice processes modeling discussed below. The geomorphic reaches defined in the Lower River are too coarse to be of much value.

Ice Processes: The ISR indicates that, currently, there is no accepted model for predicting dynamic ice processes on complex braided channels, such as those found in the Lower Susitna River downstream of Talkeetna. Project effects on the Lower River ice processes will be determined based on the magnitude of change seen at the downstream boundary of the River1D Model (approximately PRM 100) and the estimated contributions of frazil ice to the Lower River from the Middle River from observations and modelling, supplemented by simpler steady flow models (HEC-RAS with ice cover) implemented for short sections of interest in the Lower River. Based on the results summarized in the ISR, it appears that the simple HEC-RAS Model predicts an ice cover that does not change in shape or thickness with increasing discharge; it merely increases in elevation reflecting the higher water surface elevation. The preliminary results of the HEC-RAS Model provided in the ISR do not appear to adequately capture the Lower River ice processes. It is doubtful that the ice-cover option in HEC-RAS Model will provide an adequate accuracy to assess the impact on CIBW.

Prey

The primary CIBW prey species utilizing the Susitna River are eulachon and four species of salmon. Although AEA has indicated that they know they need to evaluate potential Project effects on eulachon, to date, no methods for completing this analysis has been identified. Therefore, the current suite of studies will not be adequate to address Project effects on this species.

Salmon are the focal species for all of the AEA aquatic studies. Salmon may be affected by the Project through changes in water quality (especially temperature) and changes in physical habitat (groundwater upwelling, sediment scour and deposition, leads in ice and ice buildup, water depth, stream flow, and flow fluctuations causing stranding, etc.). The studies may also be affected by inadequacy of the sampling of fish distribution and abundance. Issues related to the salmon studies are provided in more depth below.

Water Quality: Temperature is being monitored and modeled for the reservoir and downstream waters. We have no concerns regarding the ability to model temperature with the Project in place. We do have some very significant concerns regarding the evaluation of the effects of temperature changes on salmon habitat (and ultimately salmon production). At present, AEA is developing HSI curves that reflect the habitat preferences of salmonids. They are using a multivariate polynomial curve fitting process to describe the habitat associations. The preliminary curves presented in the ISR not only do not make biological sense, they do not include temperature; temperature was not found to be significantly correlated to fish abundance. Temperature is predicted to increase during winter with the Project in place. This will result in early emergence of fish and will also affect the production of zooplankton on which fish feed. The change in temperature will also affect growth and possibly timing of out migration of smolts. Therefore, it is critical that temperature be incorporated into the assessment of suitable habitat with and without the Project.

Physical Habitat: The fundamental elements of the AEA studies include the identification of the habitats conditions that fish prefer, documentation of the existing habitat conditions, and modeling of the quantity of current and predicted habitat for each of the salmon species occupying the river. Section 3 of this memo identified issues related to these efforts. Some of the larger issues are summarized below.

One of the primary areas of concern is the focus of the studies on the “Focus Areas”. These areas were not randomly selected, but rather were purposely biased towards habitats that are preferred by salmon. Therefore, the Focus Areas cannot be assumed to be representative of the portions of the river that lie outside of these areas. The reliance on non-random, heavily biased study sites is creating problems in many of the studies. The ISR, Section 8.5, provides an example of this. This section addresses the extrapolation of results of modeling within the Focus Areas to other portions of the river. No preferred approach to completing this has been identified. All three of the proposed approaches are fatally flawed from a statistical perspective. The proposed approaches to extrapolating results to the rest of river are, therefore, unlikely to reflect actual conditions in the river with and without the Project in place.

The geomorphic reaches defined in the Lower River are too coarse to be of much value. Many of the studies stratify the data collection efforts by geomorphic reach. Since the geomorphic reaches, as defined, often include narrow channels, braided channels, low and high gradient channels and often also have large tributaries entering them in mid-reach (meaning flow is also not consistent), those reaches do not represent a consistent set of conditions. The geomorphic reaches should be re-defined to reflect the variations in larger scale physical processes in the river. This would improve the quality of the data collected by several of the studies and will also improve the accuracy of the various modeling efforts.

Very little data is being collected in the Lower River. The initial evaluation of expected Project effects on stream flow and sediment transport indicates potentially significant changes in both parameters in the Lower River. Changes in stream flow and sediment transport will affect geomorphology, ice processes, and the abundance and quality of fish habitat in the Lower River. All of the aquatic studies should be extended into the Lower River. We acknowledge that the Lower River will be harder to work in than the Middle River, but working in the Lower River is not prohibitively difficult.

We question whether the data being collected will be adequate to support a valid analysis of potential Project effects on fish habitat. We recommend that the detailed approach for completing the analytical steps identified in the FSP and the ISR for the Instream Flow Study (8.5) be developed and circulated to the TWG for review.

Water Quality (Mercury)

The primary water quality parameter that has the potential to directly affect CIBW is exposure to mercury. All other parameters of concern (e.g. temperature) affect CIBW indirectly through modifying the physical environment or impacting prey. The indirect effects of water quality changes associated with the Project were discussed previously. There are several fundamental flaws with the water quality studies, including the water quality and mercury studies as they relate to potential exposure of CIBW to mercury. These include:

The Mercury Study, including the modelling, is focused on mercury concentrations in the reservoir and the potential contamination of fish and wildlife using the reservoir and its surrounding habitats. The study does not address downstream transport of mercury. Therefore, the potential Project effects on mercury exposure on downstream biota are not being addressed.

Salmon and eulachon are not included in the tissue sampling portion of the Mercury Bioaccumulation Study.

Salmon, eulachon, and CIBW have not been identified as targeted receptors for the bioaccumulation evaluation.

In addition, modelling of mercury in the reservoir is incomplete. As currently planned, the studies will not address potential exposure of CIBW to mercury through direct contact and/or through ingestion of prey.

A downstream component could be added to the study. This would require additional geological study to provide information needed to model sediment/mercury interactions. It would also require addressing mercury exposure to, and bioaccumulation in, zooplankton, salmon, and eulachon. Accumulation of mercury in targeted species, including CIBW, through ingestion would likely need to rely on the existing literature relating concentration in water and prey to accumulation in the targeted species.

Critical Issues

Additional data collection (all aquatic studies) is needed in the Lower River to support the assessment of potential Project effects on the Lower River habitats.

Preliminary evaluations of the likely Project effects on stream flow and sediment scour and deposition indicate that significant changes are likely to occur in the Lower River with the Project in place. Habitat characterization data, fish distribution and abundance data, water quality data, geomorphology measurements, and other data collection efforts, are inadequate to predict potential Project effects on the Lower River.

The analytical methods for assessing potential Project effects on salmon have not been completely documented and analytical methods for assessing effects on CIBW and eulachon have not been identified.

The geomorphic reaches defined in the Lower and Middle River, are too coarse to be of much value. Since many of the studies stratify their data collection efforts on geomorphic reach, the poorly defined reaches affect the quality of the data collected by those studies and will subsequently affect the accuracy of the various modelling efforts.

It is critical that temperature be included in the HSI curves or included in the assessment of the presence of suitable habitat with and without the Project in place.

The Mercury Study is focused only on biota in and near the reservoir. The study will not address potential exposure of CIBW to mercury through direct contact or ingestion of prey.

Additional Study Modifications

Modification 10: NMFS recommends that an approach for addressing potential Project effects on eulachon and CIBW be developed, implemented, and revised as needed, based on NMFS's review (See Additional Modification at the end).

The new study for Model Integration will focus primarily on how the numerical models interact. The location of eulachon often dictates where the beluga whales are. This modification just clarifies that beluga whales are not just moving about based on channel shape and water quality parameters.

Currently the two studies are separate and there is no feedback mechanism.

Modification 11: All studies with potential to observe belugas should record incidental sightings information; this effort should not be limited to the eulachon studies. NMFS recommends developing and distributing CIBW observation/data collection sheets to all lower Susitna River in-stream and land-based investigators who may observe CIBW in the river itself, as well as in the river delta area.

To date most work has focused on the Middle and Upper River.

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New Study Request: Integrated Modeling and Decision Support System

The goal of this request is to incorporate formally and explicitly two inter-related subjects – Integrated Modeling and a Decision Support System (DSS) - that have actually been de facto informally part of the study process since 2012. While much attention has been given to the need for integrated modeling to organize and synthesize all of the data, research, and computer models that have been parts of the study plan, adequate results have not been achieved and appear unlikely to be obtained without this focused study. Similarly, the need for a DSS that presents Integrated modeling and other results to the Alaska Energy Authority (AEA), the Federal Energy Regulatory Commission (FERC) decision makers, the general public, and other stakeholders has been discussed in Technical Working Groups, public meetings, Initial Study Report (ISR) meetings, etc., but sufficient details have not been developed.

The National Marine Fisheries Service (NMFS) finds that that the lack of progress on these two critical subjects is directly attributable to the fact that they have been relegated to secondary status precisely because they are not explicitly and formally incorporated into their own specific study plan and reporting process. Furthermore, as both the integrated modeling and DSS subjects have been deferred over and over again, it is no longer possible simply to think of or describe them as by-products of other study efforts, such as the water quality or instream flow studies. Therefore, NMFS request that they be separately identified, given weight and priority, and be given stand-alone study plan status.

NMFS does not mean to suggest that integrated modeling/DSS have not received a lot of discussion. They have. Neither does NMFS mean to suggest that aspects of integrated modeling have not been formally required in the Study Plan: They have. The requirements simply haven’t been met and efforts toward meeting them require priority. Each of these matters is discussed in detail in the following sections. NMFS believes that the discussion shows good cause for FERC to order either one New Study incorporating both the integrated modeling and DSS or two separate New Studies, one each for integrated modeling and DSS.

Just as importantly, and as described in more detail below, NMFS believes that the present study plan and priorities will not lead to the types of results that FERC/AEA are looking for when it becomes time to use the results. As far as we can tell from the cursory information available (reports from two model integration workshops and a minimal “proof of concept” effort), the present study plan and priorities have led to the situation where the studies are not being, and cannot be, integrated at a level of scientific/statistical validity that will prove satisfactory when the results are needed for decision making. Only by undertaking the focused New Study Request recommended here will it become possible to identify any weaknesses early enough in the ongoing studies to make the mid-course corrections that will be necessary to prevent the future problems and only then will it be possible to avoid wasted time, money, and effort on results that may be too limited for the critically important tasks that will be expected in order to evaluate the environmental impacts of the proposed Project and its alternatives.

To facilitate FERC's review of this new study request, NMFS will address each of the new study justification criteria set forth at 5.15(e):

5.15(e)(1) There are no material changes in the law or regulations applicable to the information request;

5.15(e)(2) The goals and objectives of the approved studies cannot be met with the approved study methodology;

All of the other studies and methodologies are discrete items directed at addressing specific information requirements in order to produce a scientifically solid basis to assess the environmental impacts of the Project for that specific study topic. With respect to model integration, many of the studies and methodologies also produce computer simulation models but those models, again, are specific to the requirements for that particular aspect of the overall Study Plan. As such, none of the studies do, nor should they be expected to do, what an integrated model would do.

Some of the studies develop models that are intended to integrate some parts of the overall Study Plan. But it is unreasonable to expect the subject area experts to be able to design and implement an integrated model that extends beyond their expertise. This element of the overall effort is so important that it warrants the special dedication of a New Study with the appropriate qualified professionals to implement it.

For example, the objective of the 8.5 Fish and Aquatics Instream Flow Study (ISF) is to characterize and evaluate the potential operational flow-induced effects on fish habitat below the proposed Project dam by establishing a set of analytical tools/models based on site-specific channel and hydraulic data that can be used for defining existing conditions (i.e., without Project) and how these resources and processes will respond to alternative Project operational scenarios.

As presently conceived, meeting the objectives of the ISF study will require the successful implementation of a complex ISF analytic framework which consists of the following project study components (8.5 in conjunction with studies 5.5, 5.6, 6.5, 6.6, 7.5, 7.6, 8.6, 9.6, 9.9, and 9.12, as they relate to the overall instream flow framework/analysis, model integration, and DSS development and application):

- river stratification and mapping of current conditions,
- study/focus area selection,
- open-water flow routing model (OWFRM) coupled with a reservoir operations model,
- development of site-specific habitat suitability criteria,
- development of habitat specific instream flow models at FAs,
- temporal and spatial habitat analyses utilizing the habitat specific ISF models, and
- ISF integration and analysis utilizing a DSS type framework.

With respect to the integration of the overall fish and aquatic ISF 8.5 study (instream flow framework-analysis, model integration, and DSS development and application) studies 5.5, 5.6, 6.5, 6.6, 7.5, 7.6, 8.6, 9.6, 9.9, and 9.12 it will be critical that they provide results that accurately represent and model current conditions and how those conditions might change as a result of constructing and operating the proposed Project. Anything less would be a failure of the analytic effort. This New Study Request simply must be undertaken now to avoid such a failure.

The overall framework that is being proposed to assess project effects on various resources throughout the Susitna River is quite complex. While the proposed framework provides a visual representation (ISR Study 8.5 figure 4.1-1) for how all the various studies are linked, stakeholders have not been provided evidence of the ability to integrate the models much less apply the results for purposes of assessing Project impacts. As but one example, in order to interpret the integrity of the model results, we need to understand what assumptions were used for hydraulic conditions, operational scenarios, modeling parameters, and boundary conditions assumptions that have not been provided.

The ISR and supporting documents do not provide sufficient information related to how the Project will be built or operated during construction or after construction. The only Project operations scenario provided in the initial ISR was related to maximum-load following (OS-1b) which was described as a worst case scenario that would most likely not be how the project would be operated. In the latest 8.5 Study Implementation Report (SIR) (Nov 2015) OS-1b was replaced with a modified scenario to reduce powerhouse discharge variability through assigning peak mode operation to other existing hydropower plants on the Railbelt grid (Integrated Load Following [ILF]-1). The AEA states that other ILF operations may be evaluated during the impact assessment but AEA currently is only modeling the ILF-1 scenario and no others, despite repeated requests from many stakeholders to develop other operational scenarios

It is not even possible to evaluate whether these statements are inconsistencies because the statements, reasoning, studies, and results are scattered across thousands of pages of material. Only with a focused and concerted effort provided by a New Study requirement will the efforts to integrate the material, produce an integrated model (or models), and weave that together with a DSS be presented in a single source document for decision makers and stakeholders to evaluate and to use as appropriate.

As yet another example related to the existing studies themselves, because of incomplete sampling across FAs and inconsistent sampling efforts within individual FAs, additional studies are needed to better understand current fish populations and habitat requirements for over-wintering fish stocks including any groundwater influenced winter habitat areas under current conditions in the Susitna River watershed (see the Requests for Study Modifications provided separately). In addition, modeling efforts to quantify and describe current water quality conditions, groundwater flow, and fish communities within the Susitna River watershed are not sufficiently described to assess the amount of uncertainty included in model outputs that are then proposed to be inputs to other models.

To further illustrate this point, there are several potential weak points in the effective combination of quantified fish response curves, measurement of physical conditions, and ability to predict physical conditions under Project alternatives that are required to implement a habitat-based evaluation. These include:

- Lateral Habitat (off the main channel) groundwater and water quality -- based on the description in the ISR, the Project will end up with categorical zones of groundwater flux (upwelling, downwelling, neutral), temperature, and dissolved oxygen (DO) for most of these habitats. Detecting and estimating how these zones change under Post-project conditions (different stages, main channel temperatures, ice cover, and bed topography) may be very difficult. This is problematic because of the strong likelihood that these off-channel habitats are very important for fish and that these unmodeled physical variables are significant (relative to depth and velocity) in these habitats.
- Winter Habitat - winter habitat assessment has the same potential problems as lateral habitat (water quality and groundwater upwelling), with additional issues of difficulty in adequately sampling and characterizing fish response curves, and the less straightforward high-resolution hydraulics. The extreme situation is winter habitat preferences for novel conditions that are currently unobservable (e.g. new mid-winter ice-free reaches under post-project operations).
- Channel change - the ISR describes long-term 1-D moveable bed simulation, short-term 2-D moveable bed simulation, 1-D ice-formation simulation, and short-term breakup simulation experiments. Nonetheless, it will be challenging to integrate multiple altered channel geometry possibilities with habitat valuations calculated from fixed geometry - especially given the episodic and difficult to model or observe geomorphic effects of mechanical ice breakup.
- Load-following - "Varial" zones resulting from intra-daily flow fluctuations have dramatic effects on primary (stranding) and secondary (mixing of main-stem surface water with longer-residence and groundwater upwelling water in lateral habitats) effects on fish. Even if we could confidently predict the resulting physical habitat conditions, there will not be Susitna-specific field data to support fish response curves to repeated intra-daily flow fluctuation. This is problematic for model prediction and validation capabilities.

As already discussed, the ISR and supporting documents do not provide sufficient information related to how the proposed Project will be operated (operational scenarios) during construction or after construction. Since even more construction alternatives, operation/maintenance alternatives, and Project alternatives, are yet to be defined and evaluated, this is indeed the time to focus that work on a well thought-out, designed, and implemented New Study.

The present Study Plan does not address these weak points in the foundational materials. As a result, it is not possible to evaluate properly those foundational materials, nor it is correspondingly possible to evaluate the computer models and decision tools that will be based on that foundation. For example, we have discussed just one sector of one of the studies: the several weak points limiting the effective combination of quantified fish response curves, measurement of physical conditions, and ability to predict physical conditions under Project alternatives that will be required to implement a habitat-based evaluation. Representing uncertainty in the effective combination of models, analysis, assumptions and measurements has no simple satisfactory solution. Fundamental spatial and temporal variation and the relevance of chosen model variables are very important. For example, a precise and accurate estimate of habitat at a single site at a specific discharge and current channel geometry does not adequately represent habitat under multiple possible sequences of discharge associated with expected flow alternatives at a range of locations.

- Current modeling efforts to quantify and describe current water quality conditions, groundwater flow, and fish communities within the Susitna River watershed are not sufficiently described to assess the degree of uncertainty included in model outputs. These output variables, based on the current data collection in the Susitna River system, must be validated against current conditions with all variations quantified before predictions of future conditions can be made from the same data.
- To date, the Project's feasible, but incomplete approach can be expected to produce estimates of an output variable (such as habitat suitability for a particular species and life stage) under a set of specific "cases" defined by study site, hydrology, and channel geometry; such as, study sites (10 Focus Areas (FAs)) under three different discharge year-types (wet, average, dry) under three different possible channel geometries (present, 25 year and 50 year). From a practical perspective that is 90 different cases/simulations for each proposed operational alternative. It is not clear from the ISR how all of this information will be integrated into a final analysis of Project-effects. This needs to be determined apriority. Further, it is not clear whether or if the analysis will provide an appropriate set of data and outcomes to represent important spatial and temporal variation in geometry, river network position, groundwater, temperature, ice formation, mechanical ice breakup, intra-annual timing of discharge and stage, and the long-term signature of extreme events. In addition, the limited scenarios and integration of current model capabilities do not address the uncertainty surrounding concerns for fish species and life stages, invertebrates, and plants that have been a critical element of responses to dam construction and operation throughout the world. The estimates from each "case" are not random samples of all possible outcomes, but can be plotted on the same graph with different colored symbols to be able to compare the variation that the proposed operational scenarios might have on instream flow habitat.

These examples are cited as but a few reasons to illustrate why the existing study approach cannot continue to treat model integration and DSS as an afterthought or a process to developed after-the-fact, receiving relatively little priority or attention as key analytic decisions—decisions that will be the foundation of the DSS—are made on an ongoing basis.

Finally, the AEA has discussed and presented general concepts related to the development of a DSS to assess Project effects on the Susitna River but are not identified in detail in the ISR or supporting documentation. This is critical information for determining the applicability of the methods and framework that will be used to integrate the numerous study results/outputs proposed and discussed above to assess the Project effects on natural resources throughout the Susitna River. It is not sufficient for the AEA to assert that their proposed matrix approach "looks" like a good way to proceed. This is a highly specialized scientific field upon which huge decisions rest. It requires a focused and dedicated Study effort.

Similarly, development and implementation of a DSS for a project as large, as complex, and representing new data collection and modeling systems (i.e., in a complex heretofore relatively unknown remote watershed in a harsh weather environment under situations of rapidly changing climate), requires focused and specialized skills. It is similarly unreasonable to expect subject area experts to be able to extend their own work to such a highly specialized technical subject.

<u>5.15(e)(3) This study request was made earlier;</u>

Although not an official study request, NMFS did emphasize the need for this work in our initial study requests, and in comments to FERC in 2013 and 2014. The level of importance for this work has risen now to the need for a formal study request because the record demonstrates that the integrated modeling/DSS are not receiving the attention and priority necessary to produce results of an acceptable quality in a timeframe that will making licensing decisions and developing measures to protect, mitigate for and enhance Project-affected resources. As required by FERC, AEA included aspects of both the integrated modeling and DSS in their original study plans as approved by FERC, but this information was too limited to be effective as demonstrated by stakeholders' requests for separate model integration workshops and AEA's development of the very limited proof of concept assessment. This work has barely begun, but those efforts demonstrated the need for dedicated efforts for stand-alone model integration and DSS work and illustrated the limitations of those exploratory efforts. This work is vitally important and should occur before efforts and resources are expended conducting studies which are not likely produce results that can be integrated as the study plan intends. These points are discussed in greater detail in the following sections.

<u>5.15(e)(4) There are significant changes in the project proposal and significant new information material to the study objectives has become available.</u>

Section (2) above illustrates that the study objectives cannot be met in the present Study Plan(s).

The proposed Project itself (design, schedule, etc.), at least as specified in the studies to date, continues to change. Alternatives to the Project have not been defined at a level of detail amenable to analysis. The ideas for how the proposed Project will be built, operated, and maintained continue to change. The foundational studies upon which evaluations of the "final" Project Alternatives, Project design, construction, and operation/maintenance continues to change. Importantly, the studies continue to yield information that will and should provide "lessons learned" to guide future studies, refine the proposed Project, and define Project Alternatives. NMFS is concerned that, without the New Study, much of that information and lessons learned will be lost in thousands more pages of reports and will not be presented in an easily understandable, accessible, and scientifically/statistically valid decision making and impact assessment process.

The Integrated Licensing Process (ILP) studies have already resulted in more than 10,000 pages of reports, analysis of the studies themselves, study variations, comments, and many Requests for Study Modifications. Just keeping track of the elements of just one of the studies is extremely difficult. The interactions between studies are almost impossible to follow. Certainly therefore, any effort to stitch it all together later on down the road into an integrated model/DSS will be correspondingly difficult to follow, much less validate, unless a New Study gives the effort the identity, visibility, and traceability that will be required.

NMFS notes that as recently as the ISR Meetings in Alaska in March, 2016, FERC reminded the AEA that they are expected to complete its development, calibration, and validation of the computer models with outputs to be included in the Updated Study Report of the ILP. And Phil Hilgert (R2) acknowledged FERCs expectation by saying, "yes, we will have to be able to demonstrate the models will work."

5.15(e)(5) This new (or, renewed) study request satisfies the study criteria in § 5.9(b).

5.9(b)(1) A description of the goals and objectives of this study proposal and the information the study will obtain;

The model integration and DSS are two distinct but closely related tasks. Model integration refers to the process of linking together the various models, data analyses, and other information from the individual studies in order to form a complete picture of existing conditions. Similarly, the tools are intended to assist the development of a scientifically sound basis to make the necessary predictions in order to identify and assess (quantify if possible) the potential impacts of the project under alternative future scenarios across multiple types of resources.

A properly designed and well supported DSS will incorporate the results of the model integration along with other qualitative (e.g., literature searches) and quantitative information (e.g., historic raw data) from other studies and provide a framework for AEA, decision makers, and stakeholders to compare the environmental impacts of alternative operational scenarios as compared to conditions without the project. The model integration and DSS are unique aspects of the project as they involve many (if not all) of the individual studies pursued as part of the FERC application for this proposed Project.

The planning and implementation for these two tasks that has already occurred is currently incorporated in Section 8.5 - Fish and Aquatics IFS of the Project (see the discussion in section (2) above). These two tasks will ultimately serve as the primary mechanisms for helping AEA, decision makers, and stakeholders understand the existing conditions in the Susitna watershed and to predict the potential impacts of the proposed Project and its alternatives. Thus, NMFS strongly recommends that a New Study be devoted solely to the topics of model integration and the DSS. In that way, it will also be possible to obtain the specialized expertise dedicated to those specific responsibilities.

The goals of the model integration and the DSS can be summarized as:

1. Integrate the numerous simulation models, data analyses, and other information generated by individual studies to predict various biological and other metrics under existing conditions, alternative design and construction plans, alternative operational scenarios, and Project alternatives.
2. Develop a DSS to assist AEA, decision makers, and stakeholders with understanding the complexity and relationships between various processes and resources throughout the watershed, as well as assist with comparing the impacts of alternative operational scenarios relative to existing conditions based on multiple evaluation metrics (see #1 above).

The specific goals related to model integration and the DSS, as stated in Revised Study Plan[1] are listed below. NMFS believes that this is too limiting a role for the tools to be developed. Such tools should not be limited to the "aquatic habitat" and the tools cannot be developed within the expertise of the aquatic resource specialists. If the tools are developed in this narrow vein, much of their value will be lost as they will not connect in an understandable way to the numerous other studies and there will be no confidence building way to confirm that the "connections" between the studies are scientifically valid.

5. *Develop integrated aquatic habitat models that produce a time series of data for a variety of biological metrics under existing conditions and alternative operational scenarios. These metrics may include (but are not limited to) the following:*
    - *Water surface elevation at selected river locations*
    - *Water velocity within study areas subdivisions (cells or transects) over a range of flows during seasonal conditions*
    - *Length of edge habitats in main channel and off-channel habitats*
    - *Habitat area associated with off-channel habitats*
    - *Clear water area zones*
    - *Effective spawning and incubation habitats*
    - *Varial zone area*
    - *Frequency and duration of exposure/inundation of the varial zone at selected river locations*
    - *Habitat suitability indices*
6. *Evaluate existing conditions and alternative operational scenarios using a hydrologic database that includes specific years or portions of annual hydrographs for wet, average, and dry hydrologic conditions and warm and cold Pacific Decadal Oscillation (PDO) phases.*
7. *Coordinate instream flow modeling and evaluation procedures with complementary study efforts including Riparian (see Section 8.6), Geomorphology (see Sections 6.5 and 6.6), Groundwater (see Section 7.5), Baseline Water Quality (see Section 5.5), Fish Passage Barriers (see Section 9.12), and Ice Processes (see Section 7.6) (see Figure 8.5-1). If channel conditions are expected to change over the license period, instream flow habitat modeling efforts will incorporate changes identified and quantified by riverine process studies.*
8. *Develop a DSS-type framework to conduct a variety of post- processing comparative analyses derived from the output metrics estimated under aquatic habitat models. These include (but are not limited to) the following:*
    - *Seasonal juvenile and adult fish rearing*
    - *Habitat connectivity*
    - *Spawning and egg incubation*
    - *Juvenile fish stranding and trapping*
    - *Ramping rates*
    - *Distribution and abundance of benthic macroinvertebrates*

[1] http://www.susitna-watanahydro.org/wp-content/uploads/2012/12/03-RSP-Dec2012_3of8-Sec-7-8-HydrologythroughInstreamFlowStudies-v2.pdf Accessed 06/21/2016

These objectives provide a high-level overview of the work underway. However, the details of these objectives are neither sufficiently clear nor specific enough. For example, it is not clear what distinctions, if any, exist between objectives 5 and 7 as many of the studies listed under objective 7 will need to be integrated to achieve objective 5. Furthermore, it is not clear exactly which studies and models will be integrated, let alone how the various models will be integrated.

For example, many of the models AEA is developing operate at different spatial and temporal resolutions and extents (e.g. 1D vs 2D, varying time steps or spatial grid resolutions). Various flow charts and diagrams have been provided to illustrate the conceptual linkages between various studies and models (e.g. Figures 8.5-1 and 8.5-10 in the RSP Section 8.5). While these diagrams are useful for understanding how the different studies are related, the lack of details regarding exactly which models will be linked and how has been a concern of NMFS since early in the study process.

In many cases, the output from one model will need to undergo significant post-processing and transformation before being passed as input into another model. There has been relatively little mention on how AEA intends to evaluate and manage in a scientifically and statistically valid manner the propagation and the accumulation of uncertainty through multiple models. Finally, each model is founded on a set of assumptions, and whether those assumptions are consistent between the models, and what impact the assumptions of one model may have on another is not clear.

It is NMFS's opinion that these questions cannot be answered satisfactorily unless a New Study is undertaken as soon as possible to begin the complex task of seeing just how it all fits together in an analytically sound, scientifically valid, way. Only when the inevitable questions and issues arise can the existing studies be adjusted, modified, or variances be established to address the specific issues. As discussed above, this illustrates how the existing studies and the New Study must develop in parallel and with comparable levels of commitment and effort.

NMFS requests that FERC issue an order to AEA for a New Study that we envision would have at least the following components:

- Create a new Technical Working Group of agencies, consultants, and stakeholders to:
  a. Analyze "top down" linkages and factors in designing an integrated model and DSS from the perspective of the potential users (analysts and stakeholders);
  b. Analyze "bottom up" linkages and factors in designing an integrated model and DSS from the perspective of the work that has already been done (research, literature reviews, field studies, and modeling) to identify how the linkages could tie into the top down users.
- The Technical Working Group would be assigned the responsibility to design a study framework, schedule, and milestones for the detailed work by appropriate specialists to yield a work product of one or more integrating computer simulation models to support a DSS that is credible, understandable, and accessible to decision makers and stakeholders to perform the types of analyses described in this request.
- The AEA would be assigned the task of reporting on the progress and results of the Technical Working Group, incorporating the products into the overall Study Plan,

building the integrated model(s)/DSS, and ultimately making the models and DSS available for use by decision makers and the stakeholders.

5.9(b)(2) An explanation of the relevant resource management goals of the Services or Indian tribes with jurisdiction over the resource to be studied;

Native Alaskan families, tribes, and their corporations live, work, and have major land holdings in the immediate vicinity of the proposed Project. They will be directly affected by all aspects of the proposed Project. They are major stakeholders in understanding the full depth and range of the environmental impacts of building, operating, and maintaining the proposed Project. While their local knowledge of the complex interactions of the watershed is ancient and deep, their understanding of the scientific results of the study depends on the quality of the presentation of that science to them (like all of the stakeholders). Unless the high quality model integration is complete and without a high quality DSS, the science will be very difficult to understand, both for Native Alaskans and other stakeholders.

5.9(b)(3) NMFS are resource agencies and are not required to explain any relevant public interest considerations.

5.9(b)(4) A description of existing information concerning the subject of the study proposal, and the need for additional information;

Numerous models have been or are being built to simulate various aspects of the Susitna watershed environment. Similarly, huge quantities of data, research results, literature reviews have been generated by the 58 studies conducted as part of the ILP. This information has been reported elsewhere. The key consideration with respect to this New Study Request is that presently there is no systematic way for analysts to put it all together and there is no orderly way in which stakeholders can review the results, simulate alternatives (e.g., designs, construction techniques, operational plans, operating rules, etc.) and keep track of the complex interactions throughout the watershed.

This New Study Request recognizes not only the priority that the information ultimately be useful to decision makers and stakeholders for purposes of assessing the environmental impacts of the proposed Project and its alternatives, but this Request also recognizes that not all of the information that must be considered in decision making about designs, construction plans, operating and maintenance plans, etc., is quantitative in nature and not subject to being integrated into complex computer simulation models. That said, it is utterly critical that such information is an accessible, understandable, and useful component of a DSS for the decision making ahead.

Virtually all of the consultants to the various teams (AEA's, NMFS, US Fish and Wildlife Service, State agencies, etc.) and the general public have repeatedly asked "how is all this information going to be assembled in a manner that is scientifically sound and accessible/useful to stakeholders?" Unless a directed, focused, and dedicated effort is undertaken with equal status to all other FERC ordered studies (and timetables), the evidence to date suggests the answer to the question will remain a low priority as work proceeds on other fronts.

Perhaps just as importantly, unless the model integration and DSS are built and implemented in parallel with continued development of the other ILP studies, it will not be possible for the various components to learn from each other. That is, model integration and DSS are dependent on the quality, structure/format, and associated data of the input variables. Yet, the quality, structure/format, and associated data of the input variables must be compatible with the input requirements of the integrated model(s) and the DSS. In order to be efficient and effective, they should be developed in parallel. Unless they are developed in parallel, it is not possible to be confident that the studies, data collected, or subject area specific computer models will ultimately be compatible with the model(s) that are intended to integrate them. Similarly, unless the DSS is developed with high priority in parallel with the Studies, it is likely that the ultimate utility of the DSS will be limited in ways that could have been avoided.

5.9(b)(5) An explanation of the nexus between project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied, and how the study results would inform the development of license requirements;

NMFS believe that integration of the studies, literature research, data, and other work that has occurred (or will occur) and organizing that work into a scientifically sound, statistically valid, and accessible DSS is important for stakeholders to have any realistic understanding of the full range of:

- Project design alternatives;
- Project scheduling and construction alternatives, including having the information basis to assess the direct, indirect, and cumulative environmental impacts of all of the alternatives;
- Project operating plans and their alternatives including ongoing maintenance methods and alternatives which includes having the information basis to assess the direct, indirect, and cumulative environmental impacts of all of the alternatives;
- Alternative standards and licensing requirements that FERC and other regulatory agencies might place on the construction, operation, and maintenance of the Project;
- Alternatives to the Project.

The strengths and weaknesses of the model integration and DSS to understand existing conditions in the Susitna watershed depend on both 1) the strengths and weaknesses of the individual studies that contribute model output, data, and other information to these tasks, and 2) the strengths and weaknesses of the planning and implementation of the model integration and DSS themselves.

The strengths and weaknesses of each of the individual studies that in turn contribute to the model integration and DSS will vary from study to study. Much information has been and will continue to be compiled that is not quantitative in nature. Many of the individual studies have not been completed and require further data collection, model development, model calibration, and/or model validation in order to represent existing conditions with sufficient accuracy and confidence. Considerable additional work is required to refine and test those studies and models for their predictive capability in order to be within scientifically/statistically acceptable accuracy tolerances.

Many of the limitations of the individual studies are described in detail in the comments in the ISR records, the comments on the SIR, and related Requests for Study Modifications. For example, the results of Study 7.5 – Groundwater are considered "scientifically usable and valid information for only very small portions of the watershed, primarily in FAs and for limited duration of times" (see SIR comments for 7.5 Groundwater). As another example, the validity of the water quality model developed in Study 5.6 could not be evaluated due to insufficient information about the model calibration (see SIR comments for Study 5.6 Water Quality Monitoring). Many other studies suffer from similar issues of insufficient or incomplete information about model calibration and/or validation.

With regard to the model integration itself, the only progress reported so far is the "Proof of Concept" (POC) demonstration and development of a software tool to facilitate model and data integration to support computations for the fish habitat models that was presented more than two years ago. The POC demonstration was presented at the POC Meeting (April 2014) and described in the ISR, 8.5 Fish and Aquatics ISF Study, Part C, Appendix N: Middle River Habitat and Riverine Modeling: POC. The POC provided an example of computing fish habitat based in the output from two 2D hydraulic models (SRH-2D for open water conditions, River2D for ice covered conditions), and multiple GIS-based datasets of physical conditions (e.g. channel morphology and substrate, groundwater inputs, water quality). The various inputs were combined with Habitat Suitability Curves (HSC)/Habitat Suitability Indices (HIS) to compute salmon spawning-incubation and salmonid rearing habitat for one Focus Area (FA-128, Slough 8A) in the Middle River under two scenarios (Existing Conditions and Operating Scenario OS-1b) under three representative years (dry, average, wet). AEA stated that the "POC demonstrated that the models and approaches being applied by AEA are conceptually sound and will provide the level of detail needed to evaluate Project effects." Not only is this not supported, it contradicts other AEA statements.

For example, the AEA and their consultants acknowledged that the POC demonstration had numerous limitations and did not address many of the requirements necessary for a scientifically sound model integration that accurately represents existing conditions and certainly less capacity to make predictions about the proposed Project and its impacts. The primary limitation was the POC demonstration was performed while many of the models were under development and had not yet been calibrated. While this was a useful first step to begin describing how the various models fit together, AEA has yet to demonstrate that this integration will be capable of representing existing conditions and acceptable for making predictions across multiple resources.

The now-two-year-old POC also focused on a single small reach of the river (one Focus Area), and did not demonstrate how those results would be spatially extrapolated to the entire river. Spatial and temporal extrapolation methods were discussed at the meeting, but AEA has yet to decide which method will ultimately be used. There was also no analysis of the error and uncertainty propagation from one model to the next. Each model contains some degree of uncertainty, and how that uncertainty is transferred from one model to the next is critical to ensure high confidence in the accuracy and precision of the overall results. Finally, the POC incorporated outputs from just two simulation models, and that "example inputs" were used for other models that were not yet complete to "demonstrate linkages and compatibilities." While this is a reasonable approach given differing schedules for various models, it falls short of proving that the full-scale model integration will be able to represent existing conditions with reasonable accuracy and confidence.

Meanwhile, the subject(s) of model integration and DSS have been discussed often, but without any meaningful progress. For example, model integration/DSS were discussed in the following Technical Workgroup meetings but no concerted effort followed the discussions:

- Water Resources Technical Workgroup Meeting February 15, 2013
- Fish Passage Technical Workgroup Meeting February 22, 2013, and a "Biological Performance Tool"
- Fish Passage Technical Workgroup Meeting, 3/20/2013

Similarly, Dr. Dudley Reiser and others discussed at length in an "Instream Flow, Riparian Instream Flow and Groundwater Resources Technical Workgroup" meeting on September 24, 2013, the subject of "Interdisciplinary… Study Integration and Modeling" and integrated modeling efforts. In the almost three years since, no tangible progress has been achieved toward the kind of integrated modeling/DSS that this project will require.

With regard to the DSS, AEA outlined a concept of a matrix-based approach after discussions of alternative frameworks during the November 2013 IFS-TT Riverine Modeling meeting. This approach was judged by AEA to be the "most efficient and flexible approach for Project decision making" (ISR 8.5 Part C Section 7.8.1.1.1). As conceived by the AEA, the matrix approach might allow users to compare existing conditions against alternative future operating scenarios based on multiple evaluation metrics (e.g. weighted usable area of fish habitat for different species and life stages, timing/intensity/duration of ice breakup, among others). AEA provided a conceptual example of a matrix containing a subset of evaluation metrics in Table 7.8-2 of the ISR 8.5 Part C.

NMFS believes that selection of the concept of a matrix-based DSS method is not based on a thorough understanding of either the model integration requirements or the many functions to be expected of a quality DSS tool. NMFS cannot see a pathway for a matrix-based concept to achieve the analytic objectives as outlined at the beginning of this section. Rather, NMFS believes that the lack of focused attention on these questions by qualified subject area experts has limited the AEA's understanding of what is required. NMFS believe that the only way that this can be achieved is to separate and focus on the model integration/DSS in parallel with, not subsumed under, other important subject area studies.

<u>5.9(b)(6) An explanation of how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge;</u> and

No hydroelectric project of comparable size, remote location, and complexity in a relatively unknown watershed has been proposed, much less studied in any comparable level of depth, for decades. That said, integrated watershed modeling and a corresponding DSS have become "standard" tools to evaluate proposed hydroelectric projects throughout the world. The degree of depth and sophistication varies with the size, complexity, and location of the project.

Of course, the modeling and DSS tools that are available would require considerable adaptation and data input to reflect the specific conditions of the Susitna watershed and the particular features (and alternatives) for the proposed Project. This is normal. This requires focus and specialized expertise. It also requires time and coordination with the other studies. Nothing substantive has happened on this for more than two years even as the other studies get more deeply committed to the path that they are on. Therefore this makes the New Study Request an important priority at this time.

No fieldwork is envisioned for the proposed New Study. No new scientific work is expected beyond that which is required in any case for the individual studies to be robust at the level of scientific/statistical quality that is already expected of them.

As described in section (2) above, the results of this study would greatly increase the ability of the relevant tribes to understand the proposed Project, its alternatives, and its impacts. In this way, the ability of the tribes to represent/protect/sustain their values will be improved.

5.9(b)(7) A description of considerations of level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.

The information needs have been described in previous sections of this New Study Request. The needs will not change with or without implementing this Study Request. What will change will be the satisfaction and confidence in the result. What will change will be the cost of continuous revisiting the methods intended to address the ongoing question posed above: "how is all this information going to be assembled in a manner that is scientifically sound and accessible/useful to stakeholders?" NMFS believes that the iterative development of an integration model and DSS, after all the studies have committed to their individual methods, data collection, analysis, and individual specialized approaches to individual models is completed, will prove to be the most expensive path to develop these tools. Therefore, a focused level of effort now will be less time consuming, less expensive, and more productive than proceeding in a piecemeal fashion.